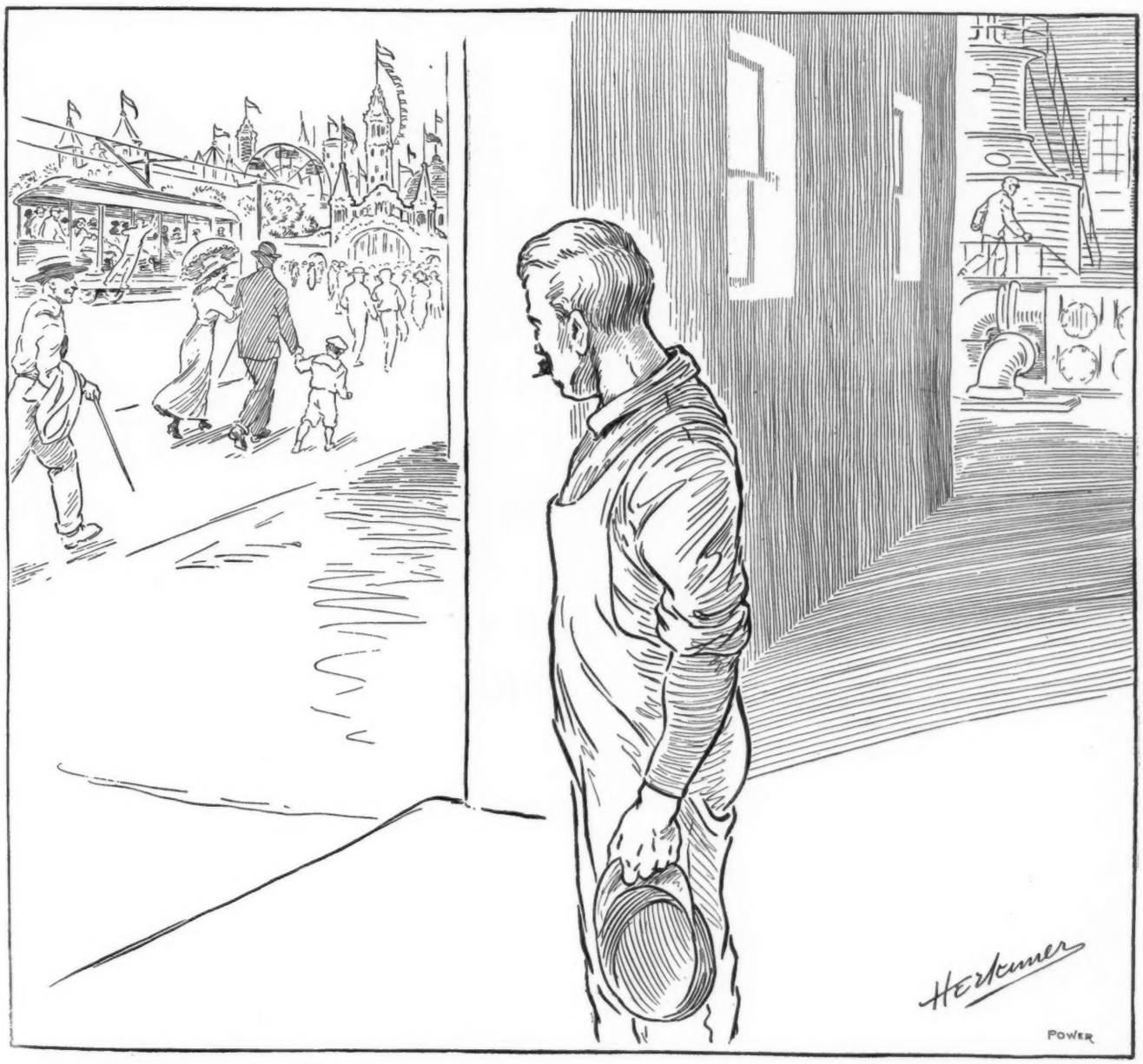
POWER

Vol. 38 NEW YORK, JULY 8, 1913 No. 2

Sunday—The Day of Rest (?)



Power Plant of the Otis Building

By A. R. Maujer

SYNOPSIS—In designing this power plant, careful provision was made for accessibility, proper ventilation and recording apparatus. Air washers have been installed, and the generating machinery is of the most modern type.

The mechanical equipment of the Otis Building, La Salle and Madison Sts., Chicago, Ill., is a good illustration of modern practice with plants of its type. The building occupies a 110x190-ft. plot, it is 16 stories high with provision for five additional stories. There are some 400 suites of rooms, accommodating 1500 people, and, in addition, 15 store spaces on the street-level floor and a large space laid out for banking purposes on the second floor.

About 4000 tungsten lamps, from 40 to 250 watts in size, and some 30 motors, ranging from 1½ to 34 hp. in capacity, furnish the electrical load for the plant. The main elevators, of the Otis electric-traction type, are nine in number, eight for passenger and one for freight service.

On May 1 of last year the power plant was put into service. The generating units are four medium-speed engines, fitted with nondetaching Corliss valve-gear, and are directly connected to direct-current dynamos which generate current at 230 volts. One 12x20-in. engine has a capacity of 100 kw.; a second is 15x24 in. with a capacity of 150 kw. and the remaining two are 20x30-in. engines, each have a capacity of 300 kw. The speeds are 200, 170 and 150 r.p.m., respectively. A view of the engine room is shown in Fig. 1.

Cylinder lubrication is by force-feed pumps and the bearings by a gravity-feed central-oiling system, the pipes of which, from the overhead tank to the engines and from the engines to the return tank, are embedded in the floor. The 30x48-in. supply tank is set on brackets just outside the engine room, 8 ft. above the level of the highest bearing. The return pipes lead the oil to a settling tank and a filter in the boiler room whence it is pumped back to the supply tank by either of two 4½ and 3¾ by 4-in. horizontal duplex pumps. A 75- and a 150-amp. compensator are used to balance the three-wire distributing system. The busbars are in duplicate sets connected with a tie switch so that the power and lighting loads can be separated, thus operating one or more of the generating units on the power load and one or more on the lighting load if desired.

An objection to electric elevators is that unless a suitable preventive is employed, the sudden heavy consumption of current when starting one or more elevator motors causes a flicker of the lights, because of the momentary drop in voltage. This is prevented in this plant by using units built sufficiently heavy for the duty. Instead of being built for the more usual guarantee of 40 deg. C., maximum temperature rise under full rated load and during continuous operation the dynamos were built to satisfy a guarantee of 35 deg. C., maximum rise. They will carry a continuous overload of 25 per cent. with a temperature rise not exceeding 43 deg. and a 50 per cent. overload for two hours with a rise not exceeding 50 deg. C. The compensators are designed to carry unbalanced

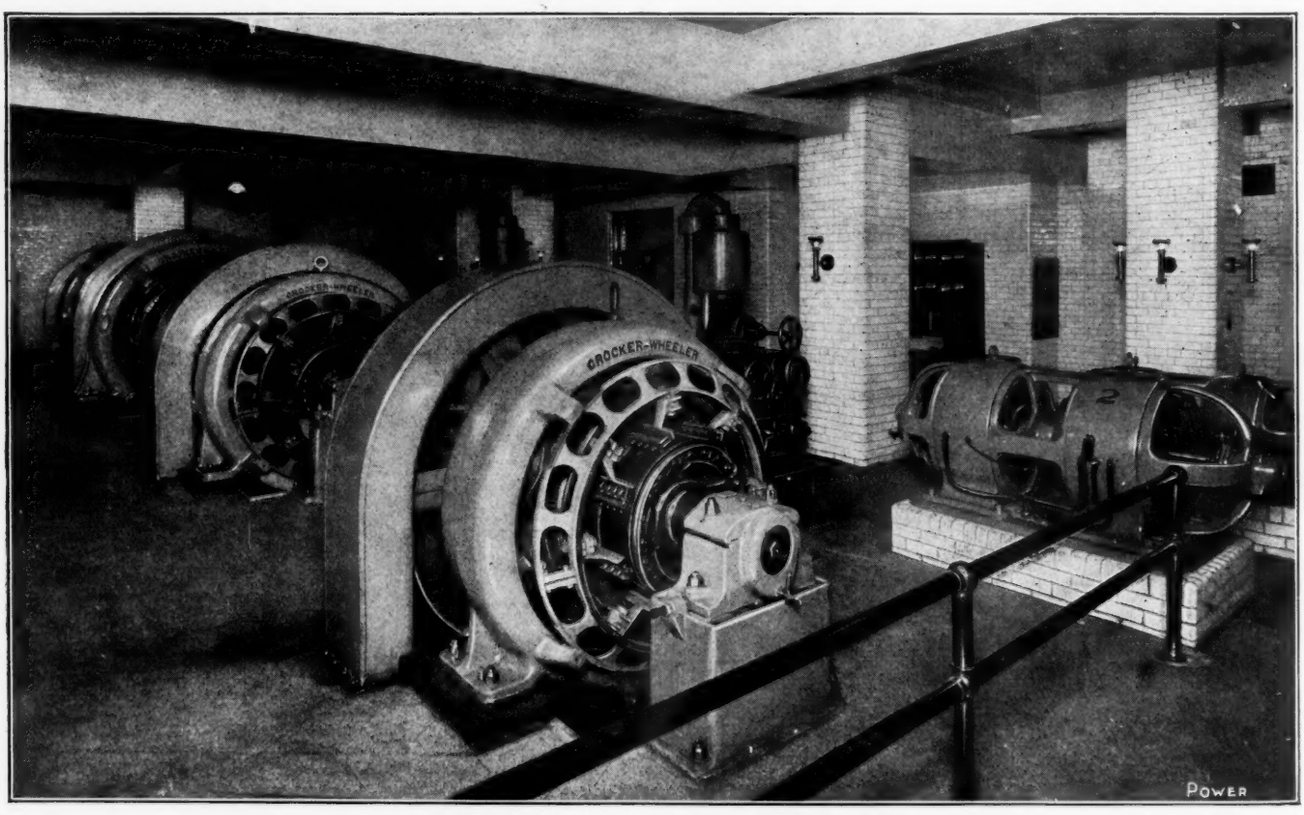


Fig. 1. Engine Room at the Otis Building

current up to their full rated capacity with a maximum variation from the average potential of not more than 1½ volts.

A 12-panel switchboard, Fig. 2, is used; the first four panels are for the generators and are equipped with the usual complement of switches and instruments. The rheostats are motor operated. The fifth and sixth panels are for the compensators and are fitted with line, rheostat and equalizer switches. The seventh panel is given over entirely to the 12 integrating wattmeters, four of which are for the main dynamos, two on the general lighting circuits; two on elevators, one on the ventilating fan-motor circuits, one on the stoker motor, one on the coal-car trolley and traveling-weight hopper feeder, and one on the coal-conveyor circuit. The next three panels carry the switches of the various main lighting circuits and the last two, the power-feeder switches.

Located on the south wall of the engine room is an automatic damper regulator which, in addition to controlling the main damper, varies the speed of the chain-grate stoker motor or engine to suit the load requirements.

A gage board, also located on the south wall, makes it possible for the engineer on watch to observe whether the various auxiliaries located in the boiler room are giving normal service. Gages also show the steam pressure in the main header, house-tank pressure, surge-tank pressure, air pressure for the thermostatic system of heating control, compressed-air receiver pressure, compressed-air pressure for the sewage ejectors, pressure in the heating-system expansion tank and the vacuum in the heating-system returns. A recording steam gage registers the main steam pressure and a differential-draft gage indicates the draft at the main damper.

A visitor entering the engine room, which is on the second basement level, 26 ft. below the sidewalk, is impressed, first, with the unusually attractive finish of the apparatus as well as of the room itself and, second, the comfortable condition of the air in the room. The walls are finished with white enamel-faced brick, the floor, with mosaic tiles, and the ceiling with a coat of light-gray paint. The machines, including the compensators, are also painted light gray.

All steam piping in the engine room is painted the same shade as the engines. The lighting fixtures are dull-brass single-light pendants from the ceiling, carrying 250-watt tungsten lamps, and single-light brackets on the building columns carrying 40-watt tungsten lamps.

The engine room is mechanically ventilated and the air is washed before it is forced into the room, purging the air of dust and dirt, cooling it in summer and humidifying it in winter. Last summer the air in the engine room was from 3 to 10 deg. cooler than on the street, even in the shade. Air is drawn in from the outside through a sheet-iron duct, the intake of which is above the roof line of the neighboring buildings, and after passing through the washer it enters the fan which forces it into the engine room. In all there are nine fresh-air supply ducts, eight located on the north wall of the engine room 8 ft. above the floor line and one in the chief engineer's office at the same height. A corresponding number of ducts located on the opposite wall at the same height conduct the foul air to the exhaust fan, which discharges it through a duct leading to the roof.

The air washer consists of a rectangular galvanized-iron compartment connected on one side with the air-intake duct and on the opposite with the ventilating fan. It contains sets of spray nozzles which form sheets of water through which the air must pass in order to reach the fan. At the inlet side of the washer is a set of tempering coils to prevent freezing in winter and for warming the air before it strikes the water and thus rendering it capable of taking up a greater amount of moisture. The nozzles are arranged in two planes so that two sheets of water are formed. The water is circulated by a 2-in. motor-driven centrifugal pump which draws its supply from the settling basin in the bottom of the washer and delivers it to the nozzles at a pressure of about 12 lb. per sq.in. After passing through the nozzles the water falls to the settling basin and is used over again. Makeup water to take the place of that which is evaporated and carried away by the air, is automatically supplied through a float valve. Once a week

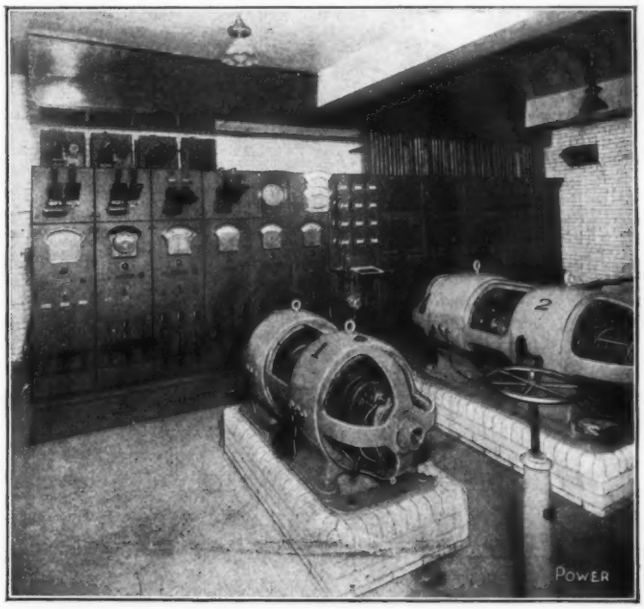


FIG. 2. SWITCHBOARD AND COMPENSATORS

the washer is cleaned and flushed out and an entirely new supply of water is put in.

After passing through the two curtains of water the air goes through the "eliminators," then through another set of heating coils and finally through the fan. The "eliminators" are simply three sets of flat deflector plates extending across the path of the air and set at an angle of 45 deg. These eliminate the particles of entrained water in the same manner that a steam separator eliminates moisture from steam.

There are four other washers in the plant, employed for cleansing the air used in as many other parts of the building. The engine-room air washer has a capacity of 12,000 cu.ft. per min. and requires the circulation of 75 gal. of water per min. for this duty.

BOILER ROOM

In order to economize in width and in height, part of the boiler room extends under the engine room, as shown in Fig. 3, and numerous pieces of apparatus which do not require much head room, such as pumps, compressors,

etc., are located in this part. A plan view of the boiler and pump rooms is shown in Fig. 4.

There are three 300-hp. water-tube boilers, equipped with chain-grate stokers and baffled vertically. Under ordinary conditions the stoker shaft is belt connected to and driven by a 7½-hp. motor. In emergencies the motor belt is slipped off, the belt to a 5x5-in. vertical steam engine is slipped on, and the stokers are driven by the latter.

Flue gases are lead through a sheet-iron flue of gradually increasing sectional area to a 7-ft. steel stack, 250 ft. high, lined with vitrified asbestos. This stack rises through a square shaft in the building and extends 30 ft. above the roof. A plan view of the engine room and a partial plan view of the boiler room is shown in Fig. 5. Fig. 6 is a view in front of the boilers.

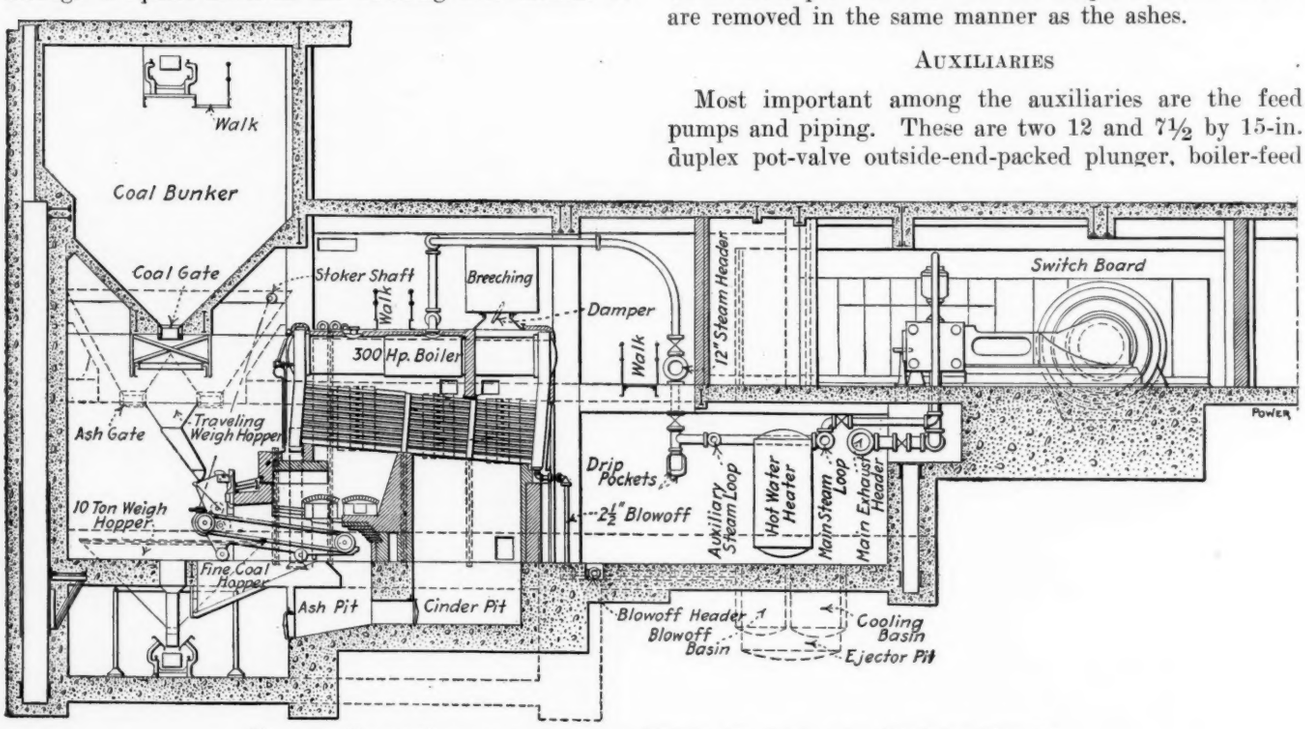


FIG. 3. CROSS-SECTION THROUGH PUMP, BOILER AND ENGINE ROOMS

Coal is delivered through the Illinois tunnel into a side tunnel connecting with the building in cars of three tons capacity, drawn by electric locomotives. The cars are unloaded into a 10-ton weighing hopper which delivers the coal to the 24x18-in. buckets of the coal and ash conveyor. The conveyor extends up the end wall of the boiler room and across over the coal bunker, which is suspended over the space in front of the boilers. It returns down the opposite wall and under the floor, Fig. 7, where it receives the ashes and delivers them to the ash bunker suspended over the end of the railroad tracks in the tunnel. The coal bunker, built of reinforced concrete, is divided into four compartments, each of which has a capacity of about 100 tons. A railroad siding is provided in the branch tunnel belonging to the building which is large enough to hold 12 coal cars. Thus, a consignment of 36 tons of coal can be switched in and unloaded when convenient.

From the bunkers the coal is fed into a traveling weigh hopper, and after being weighed is delivered through a chute to the stokers as required. This hopper runs on overhead tracks and is operated by electricity.

The space directly beneath each boiler is divided into three parts. The front part, beneath the stoker and which with ordinary hand-fired grates is the ashpit, receives the fine unburned coal which sifts through the grate. This coal is fed onto the conveyor and put back into the bunker. The middle part is the ashpit and receives the ashes as they are dropped off of the end of the grate. From this pit the ashes are fed onto the conveyor when it is not delivering coal and deposited in the ash bunker over the tracks. The rear part is beneath the last two passes of the boiler and receives any cinders which drop out of the current of gas passing through. This cinder pit connects with the ashpit and the cinders are removed in the same manner as the ashes.

AUXILIARIES

Most important among the auxiliaries are the feed pumps and piping. These are two 12 and 7½ by 15-in. duplex pot-valve outside-end-packed plunger, boiler-feed pumps. The feed pipes are in duplicate, as shown in Fig. 4. A 3-in. venturi meter with the registering mechanism located in the chief engineer's office gives a daily chart of the quantity of water fed to the boilers.

Compressed air is required at different pressures for tube cleaning, the sewage ejectors and the thermostats. Either of two single-stage, steam-driven, compressors, 8 and 8 by 8 in. in size furnish air at 80 lb. pressure, which pressure is used for the first-mentioned service. The compressors deliver the air to a 36x84-in. receiving tank from which a 36x84-in. tank for the ejectors is supplied through a reducing valve with air at 40 lb. pressure; a 24x48-in. tank for the thermostats is supplied with air at 15 lb. through another reducing valve.

Water for house service is pumped to the two 2500-gal. storage tanks on the roof by either of two 12 and 7½ by 10-in., duplex, pot-valve, outside-end-packed plunger pumps, located as shown in Fig. 8. The condensate from the heating system is pumped to the receiving tank by either of two 10 and 12 by 12-in. simplex vacuum pumps. The 48x96-in. receiver tank is suspended from the boiler-room ceiling and receives the drips from the high-pressure steam piping, the water from the boiler-furnace water backs and the cooling water from the air-compressor jackets in addition to the heating returns. The com-

pressor jacket water is first employed in the house-pump control system. The feed-water heater is fed by gravity from the receiving tank through an automatic float-operated valve. Makeup water, fed direct from the city main into the receiving tank, is also regulated by a float valve.

Hot water for house service is supplied by two closed heaters, 54 in. in diameter and 8 ft. long, each capable of heating 2500 gal. of water per hour from 40 to 170 deg. F. Each heater contains 288 brass tubes, 1¼ in. in diameter and 2 ft. 6 in. long. Because of the short tubes these heaters contain large hot-water storage space and thus are capable of satisfying momentary heavy demands. The hot water circulates by gravity, a 3-in. return pipe connects with the ends of all the main feed lines throughout the building.

As part of the building is below the sewer level, three 50-gal. automatic sewage ejectors are provided, two located in a pit in the boiler room, Fig. 9, and one in the coal-conveyor tunnel. The sewage from the low parts of the building flows to these ejectors, and is automatically discharged to the sewer, 40 ft. above, when they become filled. The ejectors are operated by compressed air at 40 lb. pressure.

Boiler-feed water is heated in a twin-type open heater. Substantially, the heater consists of two 1000-hp. units combined in one shell, which is made oval. This arrangement saves considerable piping and a number of valves and fittings without dispensing with the advantage of having a duplicate heater equipment, because one-half of the heater may be shut down for cleaning or repairs while the other half is retained in service.

High-Pressure Piping

Except for a small portion of each engine lead, all piping is grouped in the boiler room. This eliminates heat radiation and improves the general appearance of the engine room. Grouping the piping is also an advantage from the standpoint of operation and maintenance, because related valves are on the same level and all the piping can be inspected and repaired from the boiler-room floor.

A 6-in. lead from each boiler rises vertically 6 ft., connects through an elbow with an automatic stop and check

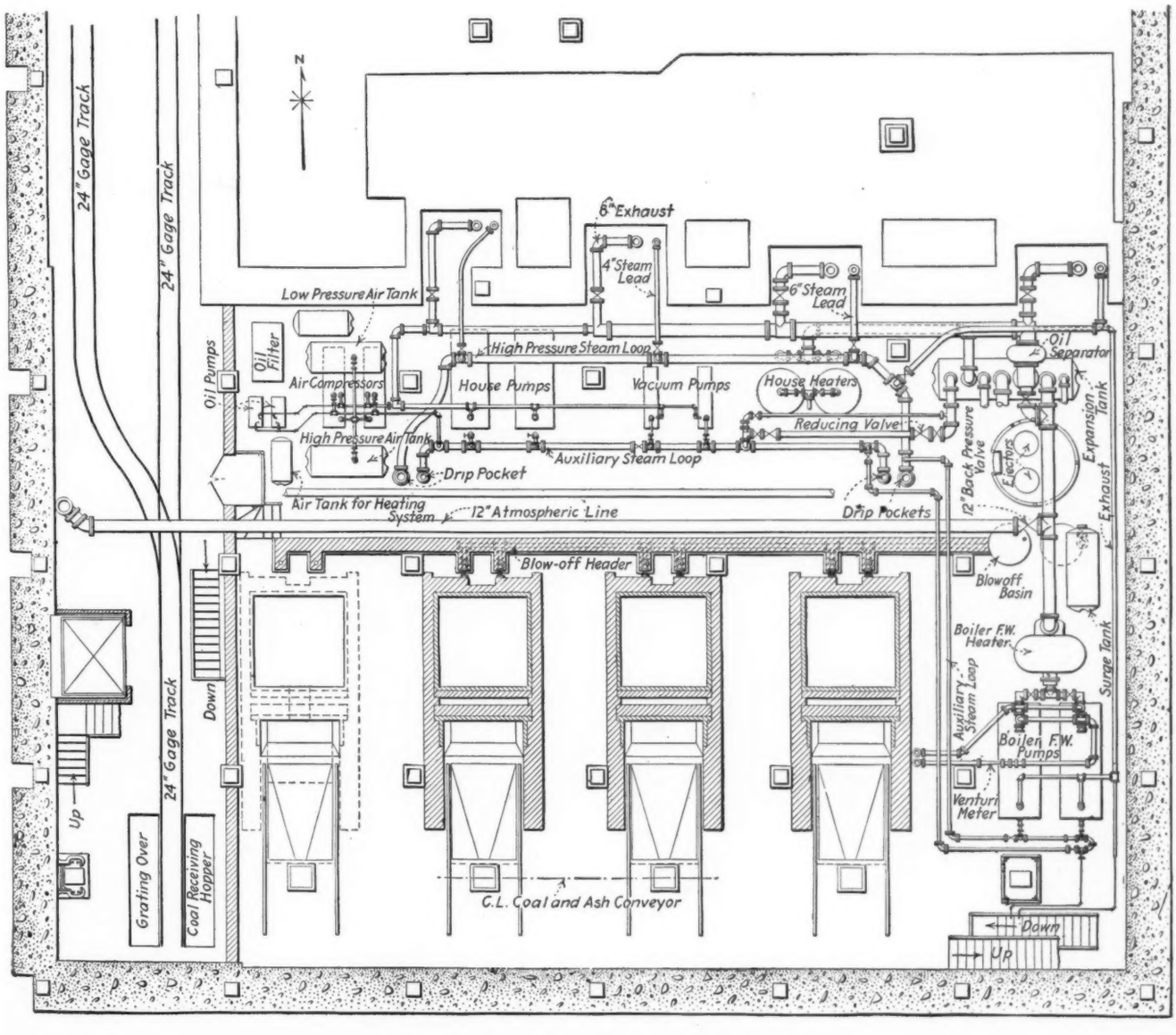


Fig. 4. Plan of Boiler and Pump Rooms

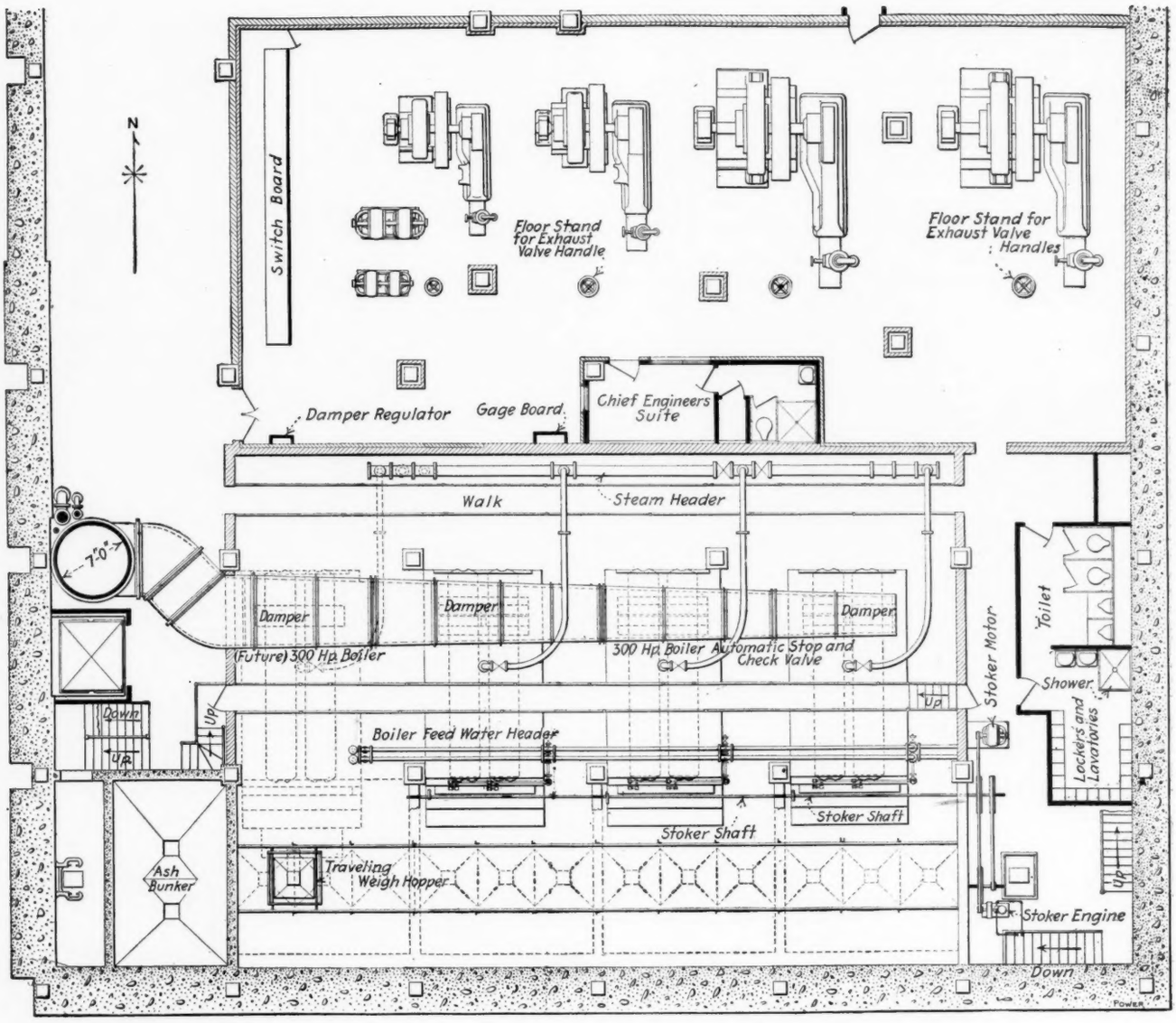


FIG. 5. PLAN OF ENGINE AND PART OF THE BOILER ROOM

valve and then through one horizontal and one vertical long-radius bend with the 12-in. main header, on the boiler-room side of the engine-room wall and slightly above the floor level of the latter room. A gate valve in each lead close to the header and one on each side of the middle boiler lead in the header itself make it possible to isolate any unit or section at will.

The principal valves are reached by iron runways, Fig. 10, which extend across the boiler room and communicate with the corridor at each side.

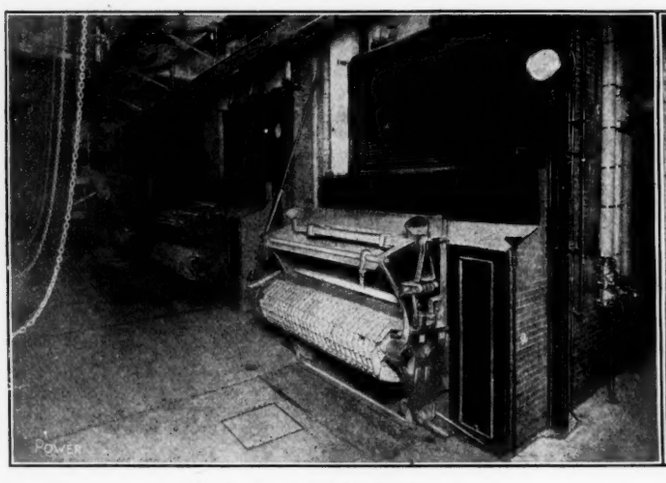


FIG. 6. THE BOILERS

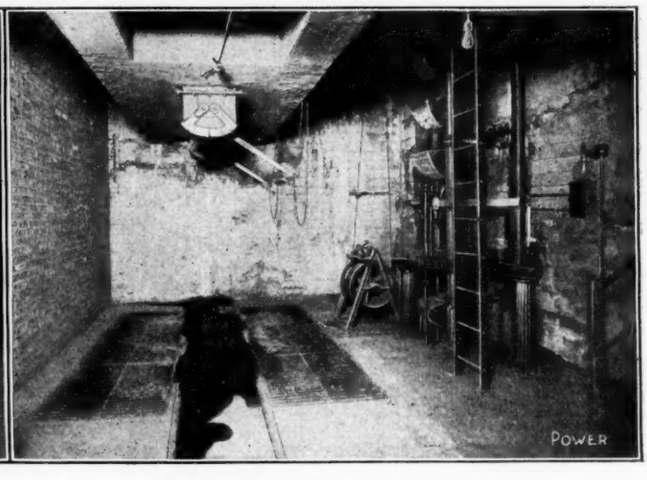


FIG. 7. ASH-HOPPER OUTLETS

An 8-in. loop, to supply only the main engines, and one leg of the 3-in. loop for the boiler-feed pumps and stoker engine, connect with each end of the main header. At the east-end, connection is made between the leads of the middle and end boiler. When the fourth boiler is installed the loop connection at the west end will also come between one boiler lead and the rest.

The loop connection at each end drops 5 ft. 6 in. straight down to the level of the horizontal portion which is hung 24 in. below the boiler-room ceiling. An ample drip pocket at the bottom of each connection leg receives the condensation from the loop which is returned to the receiving tank through the medium of a trap. The horizontal section of the loop extends 11 ft. 6 in. north through a long-radius reverse bend at one end and standard 45-deg. fittings at the other, to where the straight-run portion, 40 ft. long, lies close to and parallel with the north wall of the boiler room. Each engine lead branches out of the top of the horizontal section, extends north horizontally to a point below and to one side of the center of the cylinder and then straight up through the floor to a point a little above the cylinder, where it connects through a 180-deg. fitting with a steam separator mounted on top of the throttle.

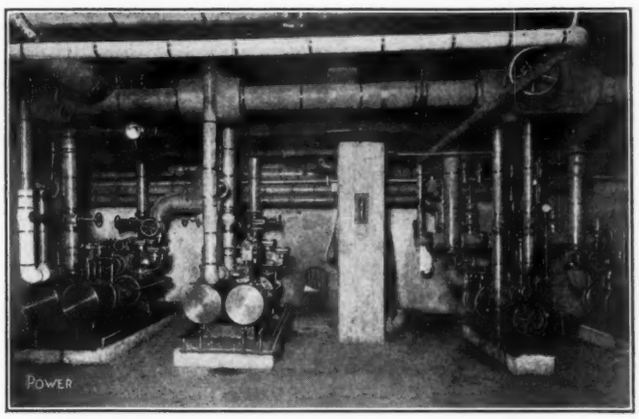


FIG. 8. HOUSE AND RETURN PUMPS

One leg of the 3-in. auxiliary loop which supplies the boiler-feed pumps and the stoker engine, branches off close to the east end of the 8-in. loop; the other leg branches off the east end of the main auxiliary loop.

This main 6-in. auxiliary loop is arranged in a manner similar to the 8-in. loop, except that the straight-run portion is but 36 ft. long and lies only 3 ft. north of the vertical legs. From this loop leads extend to the oil pumps, air compressors and the house and vacuum pumps. It is also connected with the expansion tank through a 4-in. and a 6-in. pressure-reducing valve in a line which increases successively from 4 to 6 and 10 in. in diameter. There is a 2-in. bypass around these valves for emergency use.

EXHAUST PIPING

Commencing at the vacuum pumps midway in the length of the boiler room an exhaust main of gradually increasing size extends west to collect the exhaust from the auxiliaries at that end and then returns along the north wall to the expansion tank in the northeast corner, collecting the exhaust from the main units on the way. At the tank the exhaust main is 18 in. in diameter. A 4-in. branch exhaust pipe extending south to the feed pumps and the stoker engine enters the main exhaust close to the tank. There is an oil separator in the exhaust main at the expansion tank.

From the expansion tank an 8-in. line supplies the house-service heaters; another 8-in. line supplies the ventilating fan-heating coils; a 14-in. line supplies the direct-radiation system throughout the building; a 12-in. line supplies the feed-water heater, and a 5-in. line supplies the first floor and first basement heating system.

A 12-in. atmospheric exhaust line connects with the line from the expansion tank to the feed-water heater through a back-pressure valve and extends to the roof through a pipe shaft at the west side of the building. The exhaust main is bypassed around the expansion tank to the 12-in. feed-water heater line so that the tank can be cut out without cutting out the heater also.

All steam and water piping is extra heavy with screwed flanges and flanged fittings and is covered with 1½-in., 85 per cent. magnesia covering.

OPERATING RECORDS

C. H. Langs, chief engineer, under whose supervision the plant was designed and erected, wisely provided means for acquiring and placing on record complete operating data. The means of acquisition are coal- and ash-weighing equipment, feed-water meter, wattmeters on the vari-

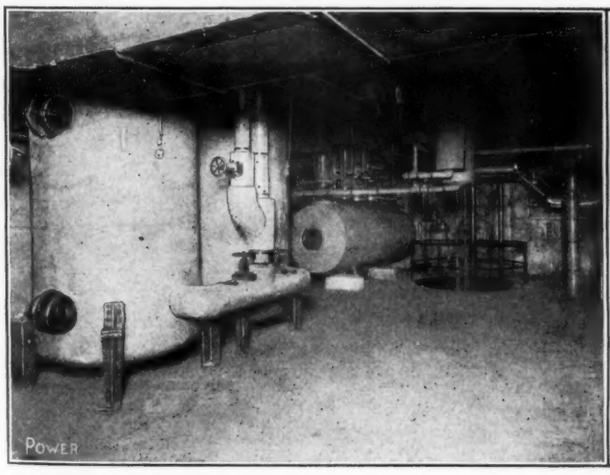


FIG. 9. HEATER, RECEIVER AND EJECTOR

FIG. 10. MAIN STEAM HEADER

PRINCIPAL EQUIPMENT OF THE OTIS BUILDING POWER PLANT

No.	Equipment	Make	Purpose	Kw.	Volts	R.p.m.	Size	Pres. lb.	Hp.	Manufacturers
1	Engine	Ball	Main units	...	...	200	12x20″			Ball Engine Co.
1	Engine			...	...	170	15x24″			
2	Engines			...	...	150	20x30″			
1	Generator	Direct current	Main units	100	230	200	.....			Crocker-Wheeler Co.
1	Generator			150	230	170	.....			
2	Generators			300	230	150	.....			
1	Air washer	Kinealy	Washing air	...	...	...	.....	..	...	Kauffman Heating & Engineering Co.
3	Boilers	Water tube	Steam gen.	...	...	...	.....	..	300	Edge Moor Iron Co.
3	Stokers	Chain	Boiler furnace	...	...	...	.....	..	...	Green Engineering Co.
2	Pumps	Duplex	Boiler feed	...	...	...	12x7½x15″	..	...	Henry R. Worthington
2	Compressors	Single stage	Air	...	...	...	8x8x8″	80	...	Laidlaw-Dunn-Gordon Co.
1	Meter	Venturi	Water	...	...	...	3″	..	...	Builders Iron Foundry
2	Pumps	Duplex	Tanks	...	...	...	12x7½x10″	..	...	Henry R. Worthington
2	Pumps	Simplex	Returns	...	...	...	10x12x12″	..	...	Union Steam Pump Co.
2	Heaters	Closed	House water	...	...	...	54″	..	...	Wm. Barawanath & Son
3	Ejectors	Automatic	Sewage	...	...	...	50 gal.	..	...	Merritt & Co.
1	Heater	Open	Feed water	...	...	...	.....	..	...	Elliott Co.

ous circuits and mileage recorders on the elevators. The means of recording consist of a complete set of report sheets, part of which is shown herewith, arranged for filing in loose-leaf books.

To begin with, there is a "Coal Received" report. This shows the time of receipt and the weight of each shipment and the section of the bunker to which it was delivered; also, the time and weight of ash removals. Then, there is a daily "Coal Burned" report. This shows the amount of coal burned in each boiler during each watch and the section of the bunker from which the coal was derived.

Thus, with these two reports, is shown the amount of coal received, on hand and burned each day; and the latter in connection with the feed-water meter record shows in a rough way the relative amount of work done by each boiler.

A daily wattmeter report, not shown, is made, which gives the total current generated, the current distribution and consumption, and which, when used in connection with the elevator-service report and other records, is important in estimating operating costs and similar data.

It is also useful in estimating repair and operating costs for the elevator equipment.

Finally, there is the daily engine-room report, Fig. 11, which gives the ammeter readings on the generators and the operating records of all the important apparatus in the plant as well as a summary of the coal consumed, ashes handled and evaporation obtained.

Otis Building
Engine Room Daily Report

Date_____ 191___

AMPERE READINGS								HOURS OF SERVICE					REPAIRS, ETC.
Time	1	2	3	4	Volts	Amperes	MACHINE	Started	Stopped	Started	Stopped	Hours on	
7.00 a.m.							Generator No. 1						
8.00 "							" No. 2						
9.00 "							" No. 3						
10.00 "							" No. 4						
11.00 "							Compensator No. 1						
12.00 m.							" No. 2						
1.00 p.m.							Oil pump No. 1						
2.00 "							" " No. 2						
3.00 "							House pump No. 1						
4.00 "							" " No. 2						
5.00 "							Air compressor No. 1						
6.00 "							" " No. 2						
7.00 "							Vacuum pump No. 1						
8.00 "							" " No. 2						
9.00 "							Live steam on bldg.						
10.00 "							" " " "						
11.00 "							Hot water heater No. 1						
12.00 "							" " " No. 2						
1.00 a.m.							Ejectors						
2.00 "							Boiler No. 1						
3.00 "							" No. 2						
4.00 "							" No. 3						
5.00 "							" No. 4						
6.00 "							Boiler feed pump No. 1						
	Total Ampere Hours						" " " No. 2						
	" K. W. "						Stoker No. 1						
COAL AND ASHES							" No. 2						
Coal—1st shift							" No. 3						
" 2nd "							" No. 4						
" 3rd "							Coal conveyor						
Ashes—1st shift													
" 2nd "													
" 3rd "													
Coal received													
Venturi meter													
Evaporation per lb. coal		lbs.											

FIG. 11. DAILY REPORT SHEET

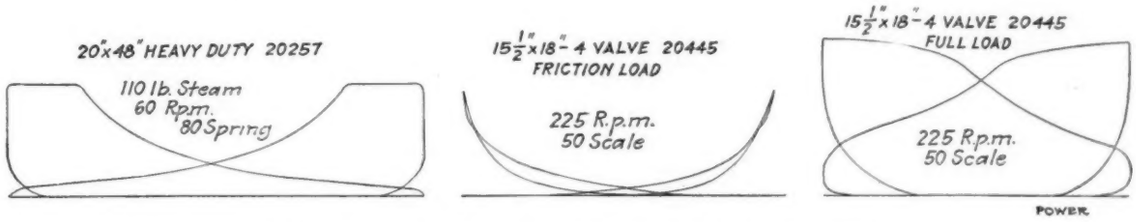
Corliss versus Four-Valve Engine

By C. R. McGahey

In the present discussion we are considering only those engines having four round valves of the Corliss type. There is merit in a properly built four-valve engine, but many of them are not equal to the Corliss engine in economy. The builders of four-valve engines admit the advantage gained by the quick movement of the Corliss valve over the manner of obtaining quick movement of a valve operated by a nonreleasing gear, as with the four-valve engine.

Superheating the steam by wire drawing, would certainly be very limited in the four-valve engine, and I attach no importance to statements pretending to make this a good feature of such engines.

The diagrams shown are from a four-valve engine having the valves in the cylinder body and using Corliss double-ported valves, with the steam ports on the lower part of the circle. This engine, 15½x18 in., showed a steam consumption of 24 lb. per i.hp., with an initial pressure of 100 lb., 225 r.p.m., and exhausting directly to the atmosphere. I have run tests on this four-valve engine in connection with a surface condenser, and it showed equal results, as compared with Corliss condensing or noncondensing. With this gear the valves on this four-valve engine have a large throw, much more than the ordinary four-valve engine, and double-ported instead of triple-ported valves. Consequently there is less port clearance space through the valve.



Diagrams from Corliss and Four-Valve Engines

Many of the four-valve engines that port above a center of a circle will leak, as the valve will wear away from its seat and the clearance will be considerably increased. At 220 r.p.m. this 15½x18-in. engine gives a piston speed of 665 ft. per min. To compare this with an 18x36-in. Corliss engine running at 90 r.p.m., we would have practically the same horsepower and a piston speed of 540 ft. per min., and this speed may be increased up to 665 ft. per min. There is but little question as to this latter engine showing a better economy than the four-valve engine. The steam or waste clearance is greater on the four-valve than that on the Corliss, being about 8 per cent. while that on the Corliss is about 4 per cent. The thermal loss is greater in the four-valve engine, as the temperature of the cylinder is changed about twice as often as with the Corliss engine.

The angularity of the connecting-rod will considerably affect the steam distribution of the four-valve engine, and the load will determine the time element in the working of the valve-gear. It will be noticed from the set of cards presented that the steam distribution of the four-valve is quite good, considering the angularity of the connecting-rod, as compared with the angularity which obtains in the Corliss engine, but the Corliss engine has no short toggles in its valve motion. The movements of the valve-gear of the Corliss are of a high velocity.

Most of the four-valve engines have so many joints in their valve-gear, and these joints are of such short radius that it is almost impossible to keep them in a good running condition. Many four-valve engines when first installed will produce an indicated horsepower-hour on 25 lb. of steam, but after a comparatively short service they take 29 lb. and more.

There is but little need for running a Corliss engine above 125 r.p.m., as it is then hard to keep the dashpots so that they will close with a velocity much above the speed of the piston. Therefore, nothing is gained by using the releasing gear. When the four-valve engine is built with proportions of about 12x24 in., good economy will be shown when running at about 165 r.p.m., as this speed will not cause wire drawing, nor require excessive port clearance to permit of the required steam velocity.

Some of the best economies that have been attained by the four-valve engine have been obtained by having a comparatively long stroke and with the cylinder completely jacketed and the valves so located as to reduce clearance to a minimum. Then, again, many four-valve engines cannot be long-range engines on account of having a shifting eccentric that will not give a constant lead.

Power from Waste Heat

West Hartlepool, England, says a consular report, which claims to be the first municipal authority to produce electricity by means of waste heat, will open its new generating station shortly. The two turbo-generators, each of 1500 kw., will be driven by exhaust steam from the furnace-blowing engines of the Seaton Carew Iron Co., adjacent to whose works the station is built. In return for their exhaust steam, which has hitherto been blowing to waste in the air, the Seaton Carew Iron Co. will receive current free from the corporation.

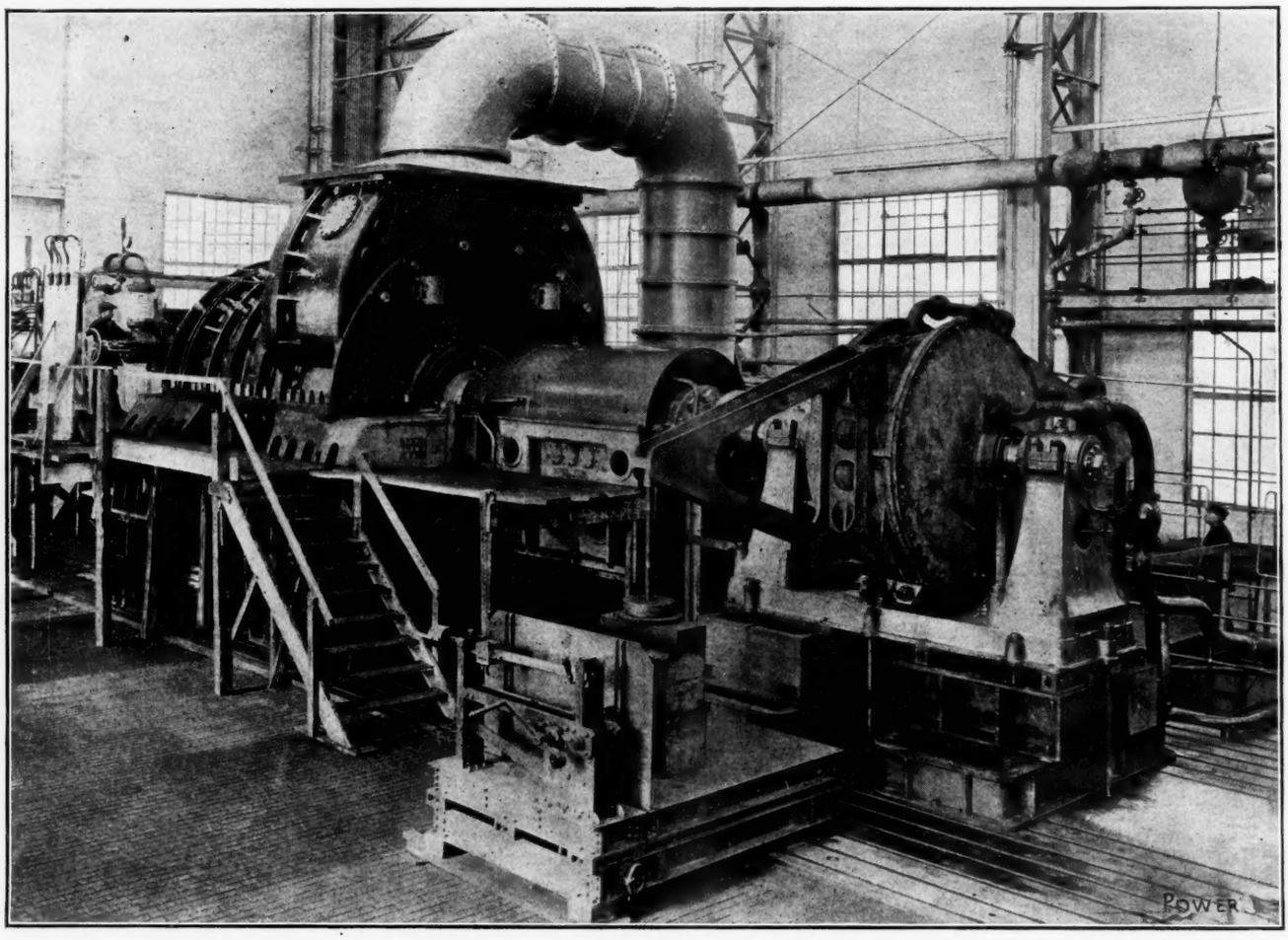
Expenditure on coal will practically be eliminated. The coal bill for the present electricity station is about $20,000 a year, and, as it is anticipated that the consumption of current will largely increase under the cheaper rate now possible, the ultimate saving by the use of waste heat will be very considerable. Should the supply of exhaust steam not be available, either through a breakdown of the blowing engines or through the iron works being idle, a supply of high-pressure steam will be obtainable from the Seaton Carew Iron Co.

The total expenditure involved in connection with the new scheme is $188,500, the plant alone having cost $150,000. The old generating station will be maintained as a stand-by and as a town substation. There the current from the new station will be transformed to the voltage required for distribution to the town.

Power Aboard the "Imperator"

SYNOPSIS—Like all up-to-the-minute liners, the "Imperator" is turbine driven, working on the triple-compound system under an initial pressure of 235 lb. per sq.in. The total horsepower of the propelling units is 62,000. The boiler-heating surface is 203,000 sq.ft., grate surface 3760 sq.ft. This is 64,000 sq.ft. more heating surface than the Cunarder "Aquitania" and 43,650 sq.ft. more than the "Lusitania," although her rated horsepower is only 2000 greater than the "Aquitania" and 6000 less than the "Lusitania." The normal speed is 22.5 knots per hour.

The quadruple-screw, turbine-driven, Hamburg-American liner "Imperator," which had its keel laid June 18, 1910, was launched May 23, 1912, and docked at Hoboken, N. J., June 19, 1913, has a wonderfully complete power plant. This is to be expected in a ship 919 ft. long, 98 ft. beam, whose height from keel to top-mast is 246 ft., and whose weight is 50,000 tons.



BRAKE TEST OF ONE OF THE "IMPERATOR'S" TURBINES

BOILERS AND DRAFT SYSTEM

Commencing with the boiler room there are 46 single water-tube boilers in four rooms, each 75 ft. long and separated from each other by water-tight bulkheads. The boiler rooms and coal bunker alongside take up the entire width of the vessel. The steam pressure carried is 235 lb. per sq.in. The draft is furnished by four fan blowers (Howden system), each of which is 13 ft. 9½ in. in diameter. The ducts conveying air from the fans to the grates are each of 45 sq.ft. cross-section. The three smoke-stacks or funnels tower 69 ft. above the upper deck. A section of one of the funnels is shown in Fig. 5. They are elliptical and measure 32 ft., on the major axis and 18 ft. on the minor axis.

ASH-HANDLING EQUIPMENT

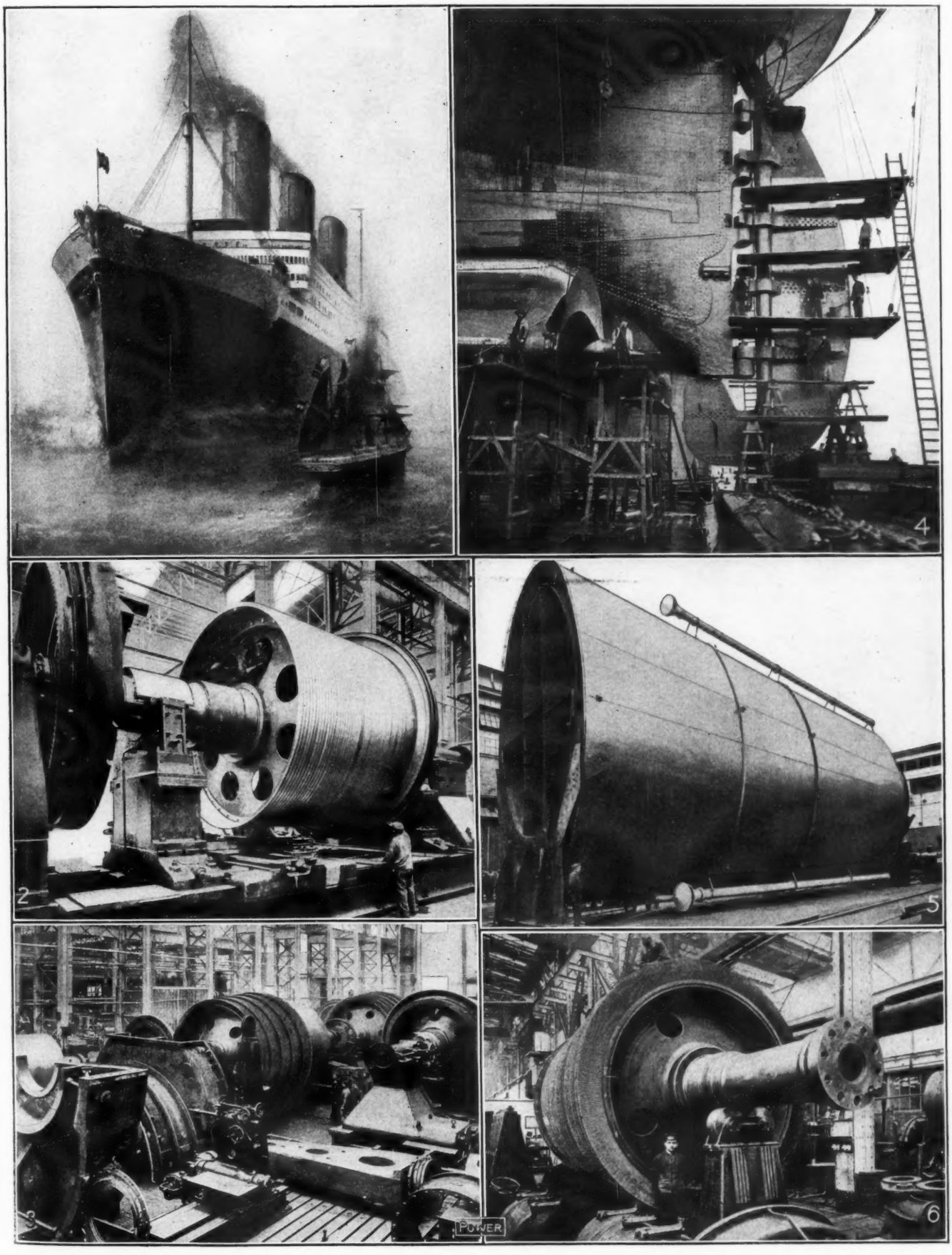
Here one finds the ash-handling equipment, consisting of a cooling apparatus, four ash ejector pumps, capable of handling 6356 cu.ft. per hr. in connection with 16 ash ejectors and six ash hoists. An idea of the amount of ash to be handled is gained from the following: Assume a coal consumption of 2 lb. per hp.-hr. and that the vessel is developing its rated horsepower of 62,000; the coal containing 10 per cent. ash. Then in 10 hr. the weight of the ashes will be

$$[(62{,}000 \times 2) \times 0.10] \times 10 = 124{,}000\ lb. = 62\ tons$$

The weight of water in the ashes due to wetting has not been considered.

HEATERS AND EVAPORATORS

Besides the four feed-water purifiers, two oil separators, two mixing feed-water heaters and two economizers, there



THE "IMPERATOR," HER RUDDER, FUNNEL SECTION AND TURBINE ROTORS

are three 2-step evaporators capable of furnishing 100 tons of feed water every 24 hours.

Turbines

The total forward driving effort of the turbines is 62,000 hp., at 185 r.p.m., through four 4-winged screws of turbadium bronze, each about 16 ft. 5 in. in diameter. The backward driving effort is approximately 35,000 hp. Ordinarily, or when going ahead, the steam passes to a high-pressure turbine on an inner shaft, then to an intermediate-pressure one, also on an inner shaft, and then on to two low-pressure turbines of equal power on the outer shafts; each turbine having its own shafts, which may be run independently for maneuvering. The reverse turbines are four in number, two high- and two low-pressure turbines with the two low-pressure machines on the outer shafts.

The total number of bronze blades in all turbines is 760,000, which, if laid end to end, would have a length of 125 miles. Each one of the low-pressure turbines, complete, weighs 380 tons and develops 16,000 hp. Each of these turbines has 50,000 blades on the rotor. Views of the rotors during construction are shown on the preceding page. One of the high-pressure turbines being tested with a huge water brake is shown on page 50.

Condenser Equipment

Four Weir dual air pumps take the condensate from the condensers and discharge it to two great tanks in the double bottom. Four duplex feed pumps take this water and, working in conjunction with the four main feed pumps, deliver it to the boilers. For port service there are two auxiliary condensers having their own two circulating and two air pumps. Two "drainage" pumps are connected with the turbine casings to draw out condensate that accumulates there.

Oil under pressure is forced to the bearings of all turbines by six pumps, while the shaft bearings are lubricated by oil supplied under pressure by two additional pumps. Four bilge pumps of approximately 37,000 gal. hourly capacity continuously pump water from the bilges of the engine and boiler rooms.

Electric Generators

Five turbo-generators, situated aft; each have a capacity of 2000 amp. at 110 volts. These generators furnish light and power, the power consumption of the various motors being about 850 hp. An emergency oil-engine-driven electric-generating set, of 100 amp. capacity, at 110 volts, is located on the boat deck and is connected so as to furnish current for the 1500-mile-range wireless apparatus as well as for lighting important parts of the ship in case of breakdown of the main electrical units. A battery furnishes current for the elaborate intercommunicating telephone system which connects every stateroom with various parts of the ship.

One gets an idea of the plumbing (under the care of the chief engineer) when it is said that in the first cabin alone there are 229 regular baths and showers, including 146 private bath rooms.

One of the screws and the steel rudder, which weighs 90 tons and is 57 ft. 6 in. high, is shown on page 51.

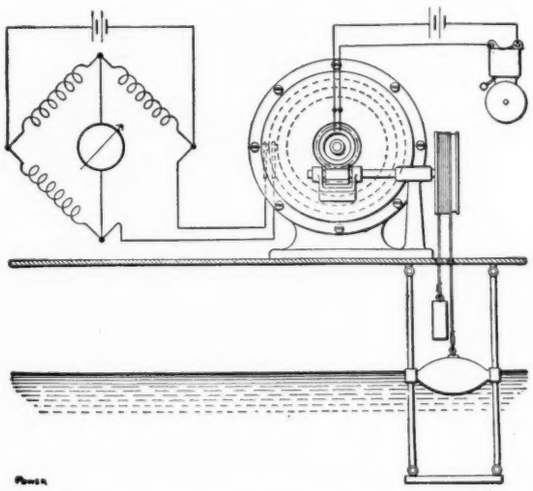
The ship carries two motor life boats equipped with wireless apparatus of 200 miles range.

Continuous Recording Remote Water Gage

The continuous indicating water gage, designed by Dr. A. Koepsel, Charlottenburg, Germany, shows on an index whether the water level is rising, falling or constant.

A mechanically variable electrical resistance is employed, so connected to a float that when the latter rises the resistance will increase and when it falls it will decrease. These variations in resistance are transmitted to a galvanometer by means of a Wheatstone bridge.

In the illustration a rope is shown wound several times around a pulley with a weight attached to one end. The other end is attached to a float which runs on guides. The vertical reciprocating motion of the float is converted into a rotary motion which is transmitted by a worm or toothed wheel to a slate disk on the periphery of which is a resistance wire, connected with electric current by two sliding contacts. By the rotation of the disk, the length of wire between the contacts, and accordingly its resistance, is altered. As the resistance forms the fourth



Continuous Recording Water Gage

branch of a Wheatstone bridge, the galvanometer in the diagonal branch of the bridge continually indicates its variations.

The apparatus is rendered independent of the distance of transmission by adding to the variable resistance a constant resistance, the amount corresponding to the resistance cut out at the leads. Any variations in the temperature of the leads can be compensated by a resistance in the adjoining branch of the bridge.

At the points of the slate disk, corresponding to the highest and the lowest positions of the float, contacts can be arranged, the closing of which sounds an alarm bell calling the attention of the staff to these two limits.

The apparatus comprises two leads and is operated either by connection to the mains or to a 2-4-volt storage battery. It has been successfully used in several installations.

The number of hydro-electric power plants is increasing steadily and rapidly throughout Japan. There are 383 companies now engaged in furnishing power and they operate 620 waterpower batteries. The total horsepower developed at the present time is over 2,000,000.

Luitwieler Double-Acting Triplex Pump

In the construction of the Luitwieler triplex pump, shown in Fig. 1, cams take the place of cranks to produce the reciprocating motion. These cams are placed 120 deg. apart on a shaft and the shape of the cams is such as to cause the plunger to produce an even flow of water throughout the complete cycle. Fig. 2 is a plan view of the pump.

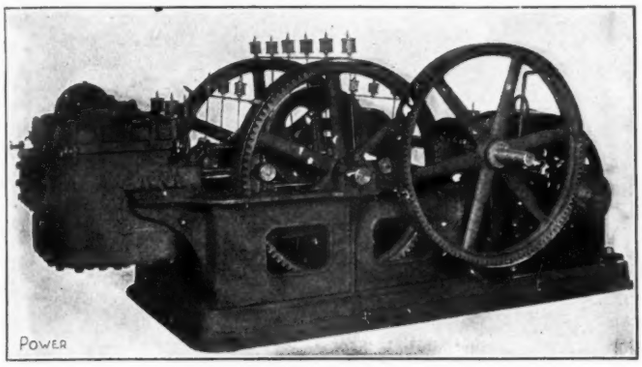


FIG. 1. LUITWIELER DOUBLE-ACTING TRIPLEX PUMP

The 3⅜-in. shaft and cams are in balance, which, with the even flow of the water, allows maintaining a high speed. In operation, the cams work against rollers, Fig. 3, at either end of the crossheads which give a reciprocating motion to the crossheads and the pistons, which are connected by rods working through packing glands. The three cams work in slots in the frame on either end of the cam shaft and the driving gears. The cam shaft rests in six bearings, each gear and cam having a bearing on either side.

As the pump is double acting, the labor performed by the cams is uniform throughout the cycle; the pressure on opposite sides of the bearings is equal and for this reason a small diameter shaft is used.

The crossheads are of bronze; the slippers move in a straight line through planed guideways. Gibs hold the slippers in place; fiber shims allow adjustment for wear. The pump is bored to receive brass linings 6 in. in diameter by 12 in. stroke. The pistons are of bronze with turned water grooves, and on each end is a leather cup which expands by the water pressure and prevents slip. The bonnets are arranged with a screw plug over each valve so that a defective valve can be immediately located, and taken out through the handhole in the center by the removal of six bolts.

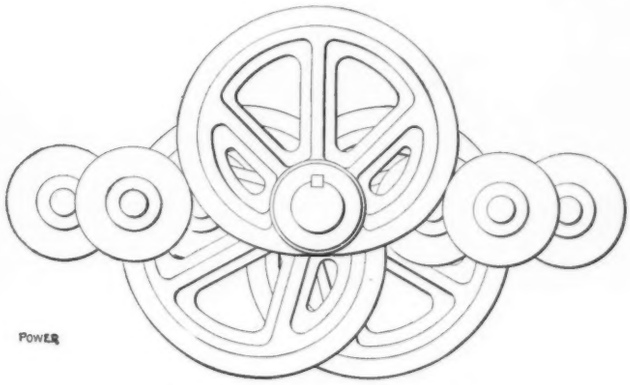


FIG. 3. CAMS AND ROLLERS

An air check and cock locates any defective valve or spring which is indicated by the action of the pressure gage. Without the use of an air chamber the gage variation is less than 5 lb., due to the closing of the valves, which indicates a small slip.

Efficiency tests made by electrical engineers report as high as 87½ per cent. efficiency in the motor-driven pump.

This pump is manufactured by the Luitwieler Pumping Co., 123 Ames St., Rochester, N. Y.

[This is a remarkable efficiency even for high-pressure delivery, and must be understood to be for the pump alone and not to include the motor.—EDITOR.]

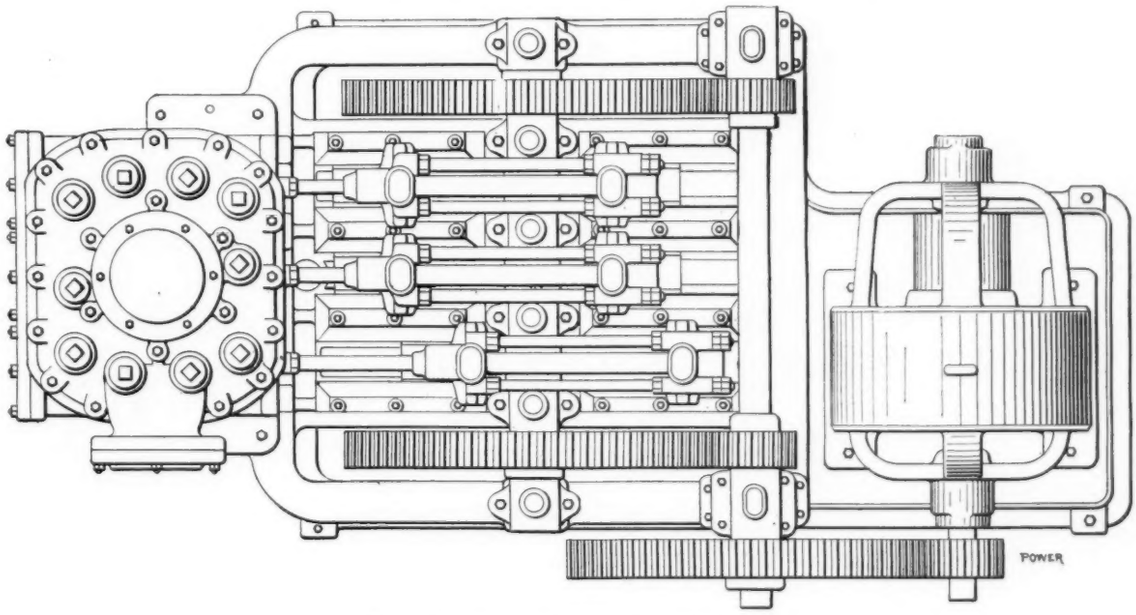


FIG. 2. PLAN VIEW OF THE PUMP

ELECTRICAL DEPARTMENT

Constant-Voltage Transmission*

By H. B. Dwight

In deciding upon the method of operation of a transmission system, two distinct alternatives are presented, one of which has been brought forward but recently. In the older method, which is the one in common use, the voltage of the system is controlled entirely from the generators. The chief disadvantage is the large variation in voltage, which is the factor limiting the carrying capacity of the system. In the newer method there is no voltage variation at all, this result being obtained by controlling the voltage from both the generating and the receiving ends. The newer method also greatly increases the carrying capacity of a transmission line, and has been used successfully in commercial operation, though as yet only on small systems.

The method in common use with transmission lines needs no description as it consists merely of controlling the voltage on the line by adjusting the voltage of the generators. At no load the two ends of the line are at approximately the same voltage, while under load there is considerable drop at the receiving end and a variation in voltage is unavoidable as the load increases or decreases.

When a load on a transmission system becomes so large as to produce too great a variation in voltage for good service, it has been customary to construct additional transmission lines, or to adopt a higher line voltage. It is at this stage that constant-voltage transmission appears most attractive, as it provides greatly increased carrying capacity without any alterations in the transmission line itself.

In the constant-voltage method, instead of controlling the voltage from one end only, synchronous motors are installed at the receiving end, and the voltage is controlled at that end by adjusting the power factor. The way in which the synchronous motors operate to hold the voltage constant is very similar to the way in which they are used to improve the power factor. A large part of the voltage drop in a transmission line is due to the line reactance, which is greatest at a low power factor, and it is, in fact, directly proportional to the lagging reactive component of the load. The drop is, therefore, changed into a rise in voltage if the reactive component is leading instead of lagging, and this may be sufficient to overcome the drop due to resistance.

When it is stated that the synchronous motors must be equal to one-half or two-thirds of the generator capacity the cost will at first sight seem prohibitive. In consideration of this, however, the additional fact must be considered that the newer method not only improves the service, but greatly increases the carrying capacity of the line. Since with a line of about 100 miles in length the cost of the generators is comparatively small compared with the cost of the line, the installation of synchronous motors will actually save money in large systems, by saving extra line construction.

The limit of carrying capacity is ordinarily set by the maximum variation in voltage allowed for good service; but if there is no voltage variation at all another limit must be looked for, and this will be found in the greatest energy loss which can be allowed for the transmission. Power for supplying line losses costs very little in most systems, so that an efficiency of 85 per cent. is generally consistent with good economy.

The carrying capacity of a 25-cycle line can be doubled by adopting the constant-voltage method, and that of a 60-cycle line can be multiplied by two or three. For 60 cycles, the cost of a constant-voltage line with the necessary synchronous motors represents a saving when the length is over 70 miles. For 25 cycles the saving over the varying-voltage method is not obtained until the length is 120 miles or more.

High reactance is a detriment to a line operating with varying voltage but is not a great disadvantage when the constant-voltage method is used. The reactance of the entire circuit includes that of the generators, step-up transformers, protective reactance coils, and step-down transformers, as well as the line reactance. It has been customary in large systems to make all these reactances as large as possible for protective reasons, in spite of the fact that they tend to make the regulation poor, and so limit the power which can be transmitted. High reactances give protection by reducing short-circuit currents, and when placed between the line and the station apparatus give very effective protection against abnormal voltages, due to lightning and to surges caused by switching. It is evident that with constant-voltage transmission it will be economical to increase all these reactances much beyond the values in use at present and better protection will thus be obtained.

It may safely be stated that the reason why the frequency of 25 cycles was adopted to any extent in this country was because its low reactance made it more economical for transmission. With constant voltage, however, 60 cycles becomes as economical as 25 cycles, and except for railway work, 60 cycles is preferable in most cases. The cost of generators, transformers, and motors is generally less at 60 cycles, and the operation of most lighting devices, especially tungsten lamps and arcs, is much more satisfactory at the higher frequency.

The most advantageous application of constant-voltage transmission is probably not in transmission lines with a single generating station, but rather in large transmission networks connecting hydro-electric plants and the cities within a radius of several hundred miles. The generators placed at various points of the network themselves partly take the place of the synchronous motors for maintaining constant voltage, and thus the total capacity of synchronous motors required is somewhat less. Duplicate lines

*From a paper presented at the annual convention of the American Institute of Electrical Engineers, Cooperstown, N. Y., June 25, 1913.

for use as reserves in case of breakdown are not required as much in networks as in straight transmission projects, since power can generally be supplied to any point from more than one direction. Thus a small number of heavy lines can be used in networks, and the constant-voltage operation is especially applicable to these.

When larger transmission networks are advocated it might be objected that the limit has been already reached as to the number of generating stations which can be connected to one network, owing to the danger from such large amounts of generator capacity when a short-circuit occurs. But a network which is operated at constant voltage contains an unusually large proportion of reactance, both in the line and in the station apparatus. Thus when a short-circuit occurs the voltage drop toward the short-circuit is very rapid and the power is delivered to it practically only from the near-by generating stations.

The two systems, varying-voltage control and constant-voltage control, have been described as being quite distinct. There is, however, a middle ground between them. For instance, consider a line operated with 20 per cent. voltage variation at the generators between no load and full load, and with a steady voltage at the receiving end. Now by installing a small number of synchronous motors at the receiving end, the generators may be operated with only 10 per cent. variation, the synchronous motors being used to hold the receiving voltage constant. Twice the number of synchronous motors would allow constant-voltage operation at both ends. It is possible, therefore, to install a small amount of machinery and obtain a proportionate improvement in closer regulation or through an increased carrying capacity of the transmission line.

Many power companies offer special terms to induce their customers to install synchronous motors and thus raise the power factor of the load. This can scarcely be called a step in the direction of using the principles of constant-voltage transmission, since the field current of the synchronous motors is not adjusted with a view toward regulating the line voltage. The advantages of a high power factor of load are very small indeed compared with the large advantages to be obtained from adjustable power factor.

It must not be supposed that the voltage at all points of a constant-voltage transmission line or network has exactly the same value. At all points where there are generators or synchronous motors whose field currents can be adjusted, the voltage will be held steady. For the best economy, however, the generator voltage should be held at a higher value than the receiving voltage. Thus the voltage at the generating stations may be held constant at 110,000 volts, while the voltage at the receiving stations may be held steady at 90,000 volts. This involves running the synchronous motors with a weak field and a lagging power factor at no load; and there is a limit in doing this when the motors are carrying a mechanical load, due to the danger of their dropping out of step. However, the capacity of synchronous motors required is so large that most of them would have to run unloaded as synchronous condensers, since mechanical loads could be found for only a few of them. The advantages and disadvantages of the constant-voltage system may be summarized as follows:

ADVANTAGES

1. Better service—no variation in voltage.
2. Better protection, due to high reactances.
3. Tendency to use the frequency of 60 cycles.
4. Increased carrying capacity of line. The limit is changed from maximum voltage variation to maximum energy loss. This allows more power to be transmitted or the distance to be increased, without the voltage being raised.
5. Lower total cost for long lines. The saving in cost is greatest for long lines or large networks, large quantities of power, large conductors, and for the frequency of 60 cycles.
6. The method is easy to apply to existing lines. The change can be gradual, and no change is necessary in line construction.

DISADVANTAGES

1. Cost and attendance of additional machinery.
2. Higher total cost for short lines.
3. In order to obtain the greatest economy from constant-voltage operation, the losses must be increased, and the number of separate lines, which are useful as reserves, must be reduced.
4. Tendency of synchronous machinery to drop out of step, and delay in putting load on the line again after shutdown.

Heating of Brush-Holder Studs

A new 300-kw., 250-volt motor-generator set was installed and from the start developed excessive heating of the brush-holder studs where contact was made with the leads.

The brush-holder studs are of standard design. Referring to Fig. 1, *AA* are heavy fiber washers; *BB* are nickle-plated iron washers, and *C* is a flat copper lead to the collecting rings to which, in turn, the switchboard cables are connected. The heating became so bad that the fiber washer *A* next to the brush-holders would burn, frequent

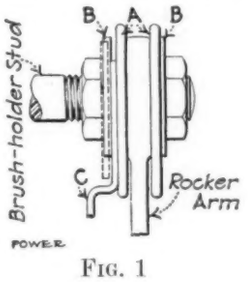


FIG. 1

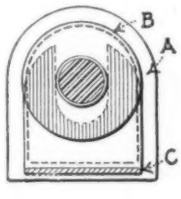


FIG. 2

FIG. 3

tightening of the nuts on the studs did not prevent the heating except for a very short time.

Upon close examination it was found that the contact of washer *B* with part *C* was not sufficient to carry the current without undue heating. The piece *C* being so far away from the brush-holder stud gave a contact similar to that shown by the shaded part of Fig. 2.

Therefore, heavy copper washers were made, shaped as shown in Fig. 3. These were substituted for washer *B* (see dotted lines, Figs. 1 and 2). Since these washers have been in use there has been no more trouble with nuts working loose, owing to the heat drying and burning out the fiber washers, and parts that were previously hot are now cooler than the studs themselves.

Michigan City, Ind. R. E. CROCKETT.

GAS POWER DEPARTMENT

Pressures in Gasoline Engines

By G. A. Field

The following curves, showing variations in per cent. of clearance, compression pressures and temperatures, normal explosion pressures, etc., in internal-combustion engines, have been grouped by the writer and found very convenient for rough calculations.

Curve 1 gives the variation of atmospheric pressure in pounds per square inch with the elevation above sea level in feet. The elevation above sea level is given from zero to 6000 ft., reading from the top of the scale downward.

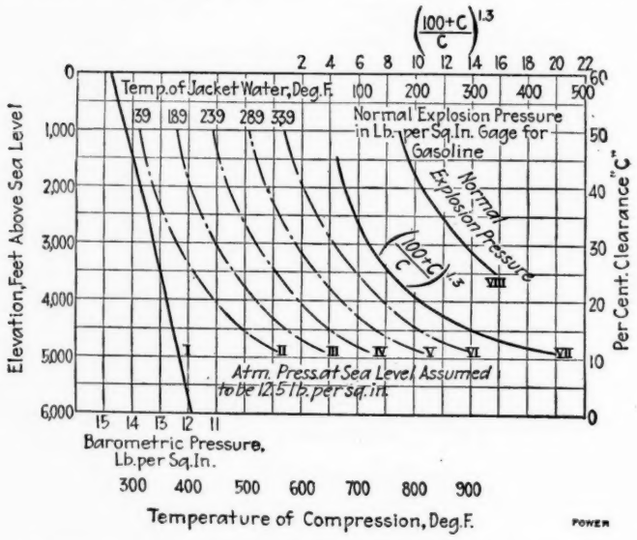

Temp. of Jacket Water, Deg. F.
139 189 239 289 339
100 200 300 400 500
Normal Explosion Pressure in Lb. per Sq. In. Gage for Gasoline
Normal Explosion Pressure
Elevation, Feet Above Sea Level
Per Cent. Clearance "C"
Atm. Press. at Sea Level Assumed to be 12.5 lb. per sq. in.
Barometric Pressure, Lb. per Sq. In.
Temperature of Compression, Deg. F.
POWER

Chart for Finding Temperatures and Pressures

The barometric pressure is given from 11 to 15 lb. per sq.in., reading from right to left.

Curves II to VI, inclusive, give the variations in temperature of compression in degrees Fahrenheit with per cent. clearance C for various temperatures of jacket water from 139 deg. F. to 339 deg. F. inclusive. The per cents. of clearance are found at the right, reading from the bottom upward, and the temperatures of compression are found at the bottom, reading from left to right. Curve VII gives the variation of the quantity $\left[\frac{100 + C}{C}\right]^{1.3}$ with the per cent. clearance C and is to be used in the formula given below for determining the compression pressure for various per cents. of clearance and elevations above sea level.

Atmospheric pressure at sea level corrected for volumetric efficiency is assumed to be 12.5 lb. per sq.in. gage. Compression formula

$$P = P_a\left(\frac{100 + C}{C}\right)^{1.3} - P_a$$

The fundamental formula for the variations of pressure and volume is

$$\frac{P_b}{P_a} = \left(\frac{V_a}{V_b}\right)^n$$

where

V_a = Volume at beginning of compression;
V_b = Volume at end of compression;
P_a = Pressure at beginning of compression—usually 0.8 or 0.9 atmospheres, depending on the volumetric efficiency;
P_b = Pressure at the end of compression;
C = Clearance (per cent. of piston displacement).

The ratio $\frac{V_a}{V_b}$ = the ratio $\frac{100 + C}{C}$.

Therefore,

$$P_b = P_a\left(\frac{V_a}{V_b}\right)^n = P_a\left(\frac{100 + C}{C}\right)^n$$

Reducing to pressure above atmosphere; i.e., subtracting P_a from both sides of the equation

$$P_b - P_a = P_a\left(\frac{100 + C}{C}\right)^n - P_a$$

Let P = Pounds per square inch gage = $P_b - P_a$, substituting,

$$P = P_a\left(\frac{100 + C}{C}\right)^n - P_a$$

In which the exponent n is usually assumed to be 1.3. Having determined the atmospheric pressure P_a for the particular elevation and corrected for volumetric efficiency, find the value of the quantity $\left(\frac{100 + C}{C}\right)^{1.3}$ for the given per cent. clearance C and solve the equation for P.

Curve VIII gives the normal explosion pressures in pounds per square inch gage for gasoline corresponding to the various values of C.

Hints on Gas-Producer Operation*

By C. H. Bromley

Conceive of an air-tight steel-plate cylinder lined with firebrick, and provided with poke openings and having a grate at the bottom, a fuel hopper and inlet at the top with an outlet for the gas, and you have the essential parts of the usual gas producer or generator. Some producers, however, do not have a grate. Consider the operation of the ordinary parlor coal stove with a "feeder" containing fresh fuel; below it the decomposed coal and then the incandescent coal above a bed of ashes and you have a good idea of the operation of the usual gas producer and of the so called "zones" of fuel. The essential difference between a stove or furnace and a gas producer is in the amount of air admitted. In the case of the former sufficient air should be admitted for complete

*Excerpts from lecture before Newark, N. J., No. 3 N. A. S. E. Association.

combustion, while in the producer only a limited amount of air is admitted under the fire.

Near the producer grate, where the air enters, a small quantity of CO_2 gas is formed. On being drawn up through the deep bed of incandescent fuel, the CO_2 absorbs considerable carbon and CO, the chief constituent of producer gas, is formed. Notice that a high CO is needed in producer operation while a high CO_2 is desired in boiler-furnace operation. As the CO increases the CO_2 decreases and *vice versa.*

Steam is admitted under the grates of a producer for two principal reasons: To lower the temperature of the fuel bed and thereby prevent fusing of the ash and the formation of clinker, and to enrich the gas with its hydrogen. Too much steam in the blast increases the CO_2 and impairs the quality of the gas. Too little greatly increases the upkeep cost of the generator by permitting the formation of clinker and destruction of the firebrick walls by fusion with the ash. Experience and the kind of fuel used will alone determine how much steam to use. Should too much moisture or water vapor get into the producer with the air, the gas will be so rich in hydrogen as to probably cause premature ignition in the engine cylinder when compression occurs. Usually the amount of water vapor entering with the air regulates itself automatically. This will be readily understood when it is remembered that the hotter the producer—when more vapor is needed—the more water will be vaporized; when the producer cools less water is vaporized.

The air entering the producer furnishes oxygen to gasify the carbon, but it also contains nitrogen, an inert gas which dilutes the producer gas. For each pound of oxygen brought in by the air, 3.33 lb. of nitrogen will have entered the producer. The gas will contain by volume about 55 per cent. nitrogen.

Incident to the function of a gas producer is the distillation of fuel within it. With bituminous and semibituminous coals and lignites the distillation process results in the formation of ammonia gas, tar and other hydrocarbons. These impurities are cared for by scrubbers, purifiers, tar extractors, etc., or they may be drawn through the bed of incandescent fuel in the producer and broken up into fixed gases.

The chief troubles of producer operation are caused by the fuel used. Bituminous and semibituminous coals frequently cake and, combined with the effect of coking, in which process the coal loses about one-tenth its weight but increases about one-third in volume, the fuel forms an arch in the producer. This arch holds the fuel above, and the fuel below does not feed down evenly. The position of the zones becomes altered and cracks are formed through which weak gas rushes to the outlet, slowing down the engine. If the steam blast is not distributed uniformly over the area of the bed, cracks and channels are likely to form, producing varying temperatures in the incandescent zone and retarding the production of rich gas. These arches must be broken by poking, but if they are poked at through doors, care must be taken to not keep the doors open too long, for sufficient air may enter as to dilute the gas and cause irregular running of the engine.

It is sometimes desirable to have connections for furnishing the engine with street gas when cleaning the generator. This is especially true for places where the labor is unskilled and where the fuel contains ash that clinkers and slags. Should the gas become weak while the producer is being cleaned the engine may be supplied with street gas.

Irregular poking and removal of the ash, varying moisture content of the coal and load fluctuations tend to alter the position of the zones.

One should be careful not to strike hard blows on the firebrick lining, as producers have been made to leak in that way. Poke from the top of the generator if possible for then the bar will move parallel with the firebrick walls and there is then less chance of breaking them.

The ignition temperature of carbon is 1240 deg. F., but a temperature of 2000 deg. F. is needed for good work in producers. At this temperature the ash often fuses, forming clinker which in turn fuses with the firebrick lining. When the clinker is removed pieces of the lining chip off with the clinker. Red coal, a semibituminous grade, fuses its ash at about 1850 to 2200 deg. F., and as the coal contains much iron the slag gives great trouble.

Coal highest in sulphur does not always have the lowest fusing point of its ash as is commonly supposed. In fact, the sulphur content of a coal is not a true indication of its clinkering properties. Organic sulphur of itself has no tendency to form clinker. When sulphur as pyrites occurs in coal and if the ash is high in silica, clinker will usually result when the temperature is as high as needed in gas-producer and boiler-furnace work.

The design of most charging boxes on gas producers is such that with reasonable care air cannot be admitted to the generator at this point to create an explosion.

Always keep in mind when running suction producers that the entire system is operating at a pressure lower than atmospheric and that leaks in the generator, scrubber, piping, etc., admit air which dilutes the gas and lowers the power of the engine. Remember, too, that cleanliness is most essential to good operation. See that all elbows in the gas lines are provided with covers held in place by yokes or that tees with plugs are used instead of elbows, so that the pipe may be easily cleaned of dust and tar. Slime and dust should be removed from the gas holder at frequent intervals. If the gas is drawn through a spiral wire brush or through screens take out the brush or screens once a week and wash them in kerosene.

When starting the plant, work the fan until plenty of gas is formed before attempting to start the engine. This will be shown by a straw-colored flame which will burn when the gas escaping at the test cock is ignited; a blue flame indicates the presence of air. When the engine has started, close the test cock and the outlet flue of the generator and work the fan until the engine is pulling hard enough to generate its own gas.

Care of Magnetos

By A. L. Brennan, Jr.

Magnetos can be divided into two classes—low-tension and high-tension, but there are certain rules that apply equally to both types. These have to do with keeping the machine free from water, oil and other foreign matter.

Magnetos invariably revolve at high speeds and consequently if the bearings are not supplied with a suitable lubricant, wear will result. This wear takes place where there is the most lateral pressure which results in the bearings being worn slightly out of line and thus the armature will not revolve upon a true center. On the other hand, overlubrication is also detrimental, inasmuch as the oil has a tendency to creep. About the best way is to resort to frequent oiling, using small amounts, say, two drops each time.

Nearly all magnetos now have permanent magnets and, therefore, an operator is seldom confronted with an inoperative magneto, due to loss of magnetism, as was quite frequently the case a few years ago. Present-day troubles are invariably attributed to faulty connections or contacts, poor adjustments, or to accumulations of oil or dirt. Troubles with low-tension magnetos are in most cases due to the frictional surfaces of the armature becoming gummed or to faulty carbon brushes.

When a magneto gives trouble it is advisable to wash the parts affected in a tin of gasoline and then polish the surfaces with fine sandpaper. Emery cloth should never be used for this purpose, as small particles of carbon are likely to cause short-circuits or partial short-circuits, which are even more difficult to locate. Carbon brushes sometimes wear unevenly but this is easily remedied by rubbing the brush upon a piece of flat sandpaper, care being taken to hold the carbon at right angles to its contact surface; this treatment will insure a positive contact.

With high-tension magnetos the most troublesome parts are the points in the breaker box, these having a tendency to become pitted and cause the motor to misfire. Ordinarily, the points need only to be cleaned with emery cloth, but if badly pitted they will probably need filing and this will necessitate their removal. It is important that they be filed at such an angle that when they are in contact they will bear over their entire surface. If the points only touch on one side, for instance, the spark efficiency will be greatly reduced.

In regard to the correct gap that should exist between these points, much depends upon the magneto. However, the majority of manufacturers supply suitable open-end wrenches and gages for all necessary adjustments and an operator cannot go wrong if he will but follow these scales.

The distributor carbons are apt to cause slight trouble by not making positive contacts, but they can be trued up easily as already mentioned. Sometimes when carbons wear considerably they do not bear with sufficient pressure to insure a positive contact, which is due to the decreased tension of the spring. This trouble is easily remedied by removing the carbon and bending out the spring.

The component parts of a spark plug should be kept tightly assembled, the points clean and about the thickness of a dime apart. Inspection of the breaker points is had by removing the cover. Some operators make a practice of cleaning out this box with gasoline, but if this is done care must be taken not to slop gasoline around, for if the motor suddenly starts the gasoline in the breaker box is likely to be set on fire.

Before removing a "set" magneto, suitable timing marks should be made, for, otherwise, trouble will be experienced when putting it back.

A Successful Marine Producer Plant

About two years ago the barkentine "Archer," a boat of 900 gross tons, operated by the Tacoma & Roche Harbor Lime Co., between Roche Harbor and San Francisco, was equipped with a suction-gas power plant. This plant has proved a decided success. Although troubles have come up now and then, they could almost always be traced to improper handling of the plant.

The producer was built in Olympia, Wash., and is of 300-hp. capacity. It is, strictly speaking, a combination up-draft and down-draft type. The gas outlet is a large tube passing down the center of the producer to within a few feet of the grate, and all the gas above the lower end is drawn down through the fuel bed, then up the tube.

The washing apparatus consists of several centrifugal washers only; no tower scrubbers nor dry scrubbers being employed. These washers have given perfect satisfaction when furnished with plenty of water. As no other washing apparatus is used, the water supply requires special attention, since the lignite produces large quantities of tar.

The engine is a 300-hp., four-cylinder Nash, running at 235 r.p.m., the exhaust line being supplied with a heater, which furnishes steam for keeping the clinkers soft in the producer. A 20-hp. gasoline-electric generating set furnishes power for the air compressors and lights when the large engine is not in operation. A generator is also belted to the larger engine, so that when the boat is under way the smaller engine is shut down.

The fuel is cheap lignite, which is so plentiful in the state of Washington. This is very high in moisture, often reaching 25 per cent. It is also high in ash, averaging about 15 per cent., and, of course, is high in volatile matter with low fixed carbon.

On the "Archer" little trouble is had with clinker when the firemen work the producer properly, but when neglected, clinkers are bound to cause more or less trouble. Some time ago the firemen decided to quit, and during the last few days they were on shift neglected the producer; the result was the formation of bad clinkers.

This lignite costs from $1.75 to $2.75 per ton in the bin, depending upon the size; the pea size giving as good satisfaction as the nut. The hoppers of the producer will not readily feed coal which is larger than nut size. A supply of coal is taken on only once for the round trip from Roche Harbor to San Francisco and back.

Only two men are on shift at a time; one fireman and one engineer. The fireman handles the producer only, and, therefore, has no reason for not keeping it in good condition. Everything is arranged very conveniently for the engineer. When starting the engine he does not have to run from one place to another to close purge valves, air valves, etc., as everything is located so that all valves can be operated right at the engine.

This plant is of special interest because it has now been in operation just about long enough to give a good idea of what can be done with marine lignite gas-producer plants. The successful performance of this installation means much to the Pacific Northwest where there are enormous fields of lignite unfit for almost any purpose except gas producers. The "Archer" was the first boat of any consequence on the Pacific coast to install gas power and it has been watched with interest.

Seattle, Wash. GEORGE W. MUENCH.

REFRIGERATION DEPARTMENT

The Properties of Saturated Ammonia Vapor

Experimental data on ammonia has been meager and the tables on the properties of ammonia which have been used are known to be inaccurate in many particulars. Realizing this fact, the University of Illinois Engineering Experiment Station has carefully analyzed the available data on the subject and worked out tables of the properties of both saturated and superheated ammonia and besides a convenient chart for solving graphically the usual practical problems met in refrigerating practice. These data appear in Bulletin No. 66, just issued.

The authors, G. A. Goodenough and W. E. Mosher, were exceptionally thorough in their investigations and are to be congratulated on producing a work which is the latest and best on the subject and should be generally adopted for standard reference. Due to lack of space only the tables on saturated ammonia vapor and liquid ammonia will be presented in this issue and for the same reason some of the intermediate values were omitted toward the end of Table 2. Following is a review of what the authors have to say concerning the tables:

As in the case of steam and many other technically important vapors, the first reliable experimental knowledge of the properties of ammonia was derived from the work of Regnault. He determined experimentally the relation between the pressure and the temperature of the saturated vapor and expressed it by means of empirical formulas. He also determined the relative volumes of the superheated vapor at different pressures along an isotherm for the temperature 8.1 deg. C., the specific heat, the theoretical density and the experimental density of the gas. The determinations made by Regnault of the specific heat of the liquid and the latent heat of vaporization were lost in the reign of the Commune in 1870; twelve of the determinations of the latter magnitude, however, have been found.

The first attempt to establish the fundamental equations for the vapor of ammonia and to compute tables of its properties was made by Ledoux. These equations and resulting tables, resting as they do upon unsound hypotheses and meager experimental data, are, in the light of later investigations, quite inaccurate. The next theoretical investigation of the subject was undertaken by Zeuner, who computed new constants for ammonia, in the equation of state of the form already applied by him to steam, and used by Ledoux for ammonia. He also constructed empirical formulas for the inner and outer latent heat, and the specific heat of the liquid, and by use of these formulas computed tables which appeared in the earlier editions of his thermodynamics. In the later editions the values thus calculated have still been used for temperatures below 32 deg. F., but results of later experimental determinations have been used above that temperature. These tables for ammonia vapor are given in both English and French units.

The tables now used most extensively in refrigeration work and included in most handbooks on refrigeration are those of Wood. These tables are computed from formulas derived by the author and based upon Regnault's experiments. About the same date (1889) that Wood's tables appeared, another set of tables was published by Peabody. These tables were based upon the work of Ledoux and upon the same form of equation of state. namely, that derived by Zeuner and applied to ammonia by Ledoux, but with the constants recomputed.

Since the above mentioned tables were published the properties of ammonia have been made the subject of considerable experimental work, although comparatively little is known even now when its importance in technical work is considered. Beside the experimental work enumerated above we have the following determinations: Pressure-temperature relation by Blümcke, Pictet, Faraday, Davies and Brill; critical temperature and pressure by Dewar, Vincent and Chappuis, Jaquerod and Schaffer; latent heat of vaporization by von Strombeck, Franklin and Kraus, Estreicher and Schnerr, and Denton and Jacobus; specific heat of the liquid by von Strombeck, Ludeking and Starr, Elleau and Ennis, and Dieterici; volume (or density) of the liquid by D'Andreeff, Lange and Dieterici; volume of saturated vapor by Dieterici; volume of superheated vapor by Leduc, Guye and Perman and Davies; specific heat of the superheated vapor by Keutel, Voller, Wiedemann and Nernst, the existing data on the latter property being summed up by Nernst. In addition to the above direct experimental determinations of the various properties of ammonia there is available a set of throttling experiments performed by Wobsa.

A great deal of the recent experimental work has been done by Dieterici. He has computed a table of the properties of ammonia, but this table is available in metric units only, and may be improved upon. In 1907, Wobsa published tables of ammonia vapor based upon his own experimental work and that of Dieterici. These tables appear in the 1908 edition of Hütte and have been converted into English units and extended for every degree Fahrenheit by Macintire. In 1908, Wobsa published a revised table based upon a new form of equation of state. Among other tables of the properties of ammonia which have appeared in metric units are those of Mollier and of Hybl.

The present investigation has been undertaken with the object of collecting and correlating the various scattered experimental data on the subject of the properties of ammonia. An attempt has been made to reconcile these data by means of well known thermodynamic laws and principles so that the results may be consistent with each other; and to express the various properties by means of formulas from which tables and charts in English units may be prepared for use in solving the many problems connected with refrigeration work.

It is fully realized that the experimental evidence is not as complete as could be desired and that more ac-

TABLE 1. SATURATED AMMONIA VAPOR: TEMPERATURE TABLE

Temp. deg. F.	Pressure, lb. per sq.in.	Sp. vol. sat. vapor, cu.ft. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid.	Latent heat of evap.	Heat content of vapor.	Internal Energy B.t.u. Evap.	Internal Energy B.t.u. Vapor	Entropy Liquid	Entropy Evap.	Entropy Vapor
−110	0.758	291.	0.00344	.....	648.5	.....	607.7	.....	.....	1.8548	.....
−105	0.947	236.	0.00424	.....	645.4	.....	604.0	.....	.....	1.8198	.....
−100	1.176	192.	0.00520	.....	642.2	.....	600.3	.....	.....	1.7857	.....
−95	1.450	158.	0.00633	.....	639.0	.....	596.6	.....	.....	1.7524	.....
−90	1.778	130.	0.00767	.....	635.8	.....	592.9	.....	.....	1.7200	.....
−85	2.167	108.	0.00924	.....	632.5	.....	589.1	.....	.....	1.6884	.....
−80	2.626	90.3	0.01107	.....	629.3	.....	585.3	.....	.....	1.6575	.....
−75	3.164	75.8	0.01320	.....	625.9	.....	581.5	.....	.....	1.6273	.....
−70	3.791	64.0	0.01564	.....	622.6	.....	577.7	.....	.....	1.5979	.....
−65	4.518	54.2	0.01845	.....	619.2	.....	573.9	.....	.....	1.5691	.....
−60	5.358	46.2	0.02165	.....	615.8	.....	570.0	.....	.....	1.5410	.....
−55	6.324	39.6	0.02530	.....	612.4	.....	566.1	.....	.....	1.5134	.....
−50	7.43	34.01	0.02940	−85.7	608.9	523.3	562.2	476.5	−0.1901	1.4865	1.2964
−49	7.67	32.98	0.03032	−84.7	608.2	523.6	561.4	476.7	−0.1875	1.4811	1.2936
−48	7.92	32.00	0.03125	−83.6	607.5	523.9	560.6	476.9	−0.1850	1.4758	1.2908
−47	8.17	31.07	0.03218	−82.6	606.8	524.3	559.8	477.2	−0.1825	1.4705	1.2880
−46	8.43	30.19	0.03312	−81.5	606.1	524.6	559.0	477.4	−0.1801	1.4653	1.2853
−45	8.69	29.34	0.03408	−80.5	605.4	524.9	558.2	477.6	−0.1776	1.4601	1.2825
−44	8.96	28.52	0.03506	−79.5	604.7	525.3	557.4	477.9	−0.1751	1.4549	1.2797
−43	9.24	27.72	0.03607	−78.4	604.0	525.6	556.6	478.2	−0.1727	1.4497	1.2770
−42	9.53	26.94	0.03712	−77.4	603.3	525.9	555.8	478.4	−0.1702	1.4445	1.2743
−41	9.82	26.18	0.03820	−76.4	602.6	526.2	555.0	478.6	−0.1678	1.4394	1.2716
−40	10.12	25.45	0.03930	−75.3	601.9	526.6	554.2	478.9	−0.1653	1.4343	1.2690
−39	10.43	24.74	0.04042	−74.3	601.2	536.9	553.4	479.1	−0.1628	1.4292	1.2663
−38	10.75	24.06	0.04156	−73.3	600.5	527.2	552.6	479.3	−0.1604	1.4241	1.2637
−37	11.07	23.40	0.04273	−72.2	599.7	527.5	551.8	479.6	−0.1580	1.4190	1.2611
−36	11.40	22.76	0.04393	−71.2	599.0	527.9	551.0	479.8	−0.1555	1.4140	1.2585
−35	11.74	22.14	0.04516	−70.2	598.3	528.2	550.2	480.0	−0.1531	1.4090	1.2559
−34	12.09	21.55	0.04641	−69.1	597.6	528.5	549.4	480.3	−0.1507	1.4040	1.2533
−33	12.45	20.97	0.04769	−68.1	596.9	528.8	548.6	480.5	−0.1483	1.3990	1.2507
−32	12.81	20.41	0.04900	−67.1	596.1	529.1	547.8	480.7	−0.1458	1.3940	1.2482
−31	13.18	19.87	0.05033	−66.0	595.4	529.4	547.0	481.0	−0.1434	1.3891	1.2457
−30	13.56	19.35	0.05168	−65.0	594.7	529.8	546.2	481.2	−0.1410	1.3842	1.2432
−29	13.95	18.84	0.05306	−63.9	594.0	530.1	545.4	481.4	−0.1386	1.3793	1.2407
−28	14.35	18.35	0.05449	−62.9	593.2	530.4	544.6	481.6	−0.1362	1.3744	1.2382
−27	14.76	17.87	0.05596	−61.8	592.5	530.7	543.7	481.9	−0.1338	1.3696	1.2358
−26	15.18	17.40	0.05747	−60.8	591.8	531.0	542.9	482.1	−0.1314	1.3647	1.2333
−25	15.61	16.95	0.0590	−59.8	591.1	531.3	542.1	482.3	−0.1290	1.3598	1.2309
−24	16.05	16.51	0.0606	−58.7	590.3	531.6	541.3	482.5	−0.1266	1.3550	1.2285
−23	16.50	16.09	0.0622	−57.7	589.6	531.9	540.5	482.8	−0.1242	1.3502	1.2260
−22	16.96	15.68	0.0638	−56.6	588.5	532.2	539.7	483.0	−0.1218	1.3454	1.2236
−21	17.43	15.28	0.0654	−55.6	588.1	532.5	538.9	483.2	−0.1195	1.3407	1.2213
−20	17.91	14.89	0.0671	−54.6	587.4	532.8	538.0	483.4	−0.1171	1.3360	1.2189
−19	18.40	14.52	0.0689	−53.5	586.6	533.1	537.2	483.6	−0.1147	1.3313	1.2165
−18	18.90	14.16	0.0706	−52.5	585.9	533.4	536.4	483.8	−0.1124	1.3266	1.2142
−17	19.41	13.81	0.0724	−51.4	585.1	533.7	535.6	484.0	−0.1100	1.3219	1.2118
−16	19.93	13.48	0.0742	−50.4	584.4	534.0	534.8	484.3	−0.1077	1.3172	1.2095
−15	20.46	13.15	0.0760	−49.4	583.6	534.3	533.9	484.5	−0.1054	1.3126	1.2072
−14	21.00	12.83	0.0779	−48.3	582.9	534.6	533.1	484.7	−0.1031	1.3080	1.2049
−13	21.56	12.51	0.0799	−47.3	582.1	534.8	532.3	484.9	−0.1007	1.3033	1.2026
−12	22.13	12.21	0.0819	−46.2	581.4	535.1	531.4	485.1	−0.0984	1.2987	1.2003
−11	22.71	11.92	0.0839	−45.2	580.6	535.4	530.6	485.3	−0.0961	1.2941	1.1980
−10	23.30	11.63	0.0860	−44.2	579.9	535.7	529.8	485.5	−0.0938	1.2896	1.1958
−9	23.90	11.35	0.0881	−43.1	579.1	536.0	528.9	485.7	−0.0915	1.2851	1.1935
−8	24.52	11.08	0.0903	−42.1	578.4	536.3	528.1	485.9	−0.0893	1.2806	1.1913
−7	25.15	10.82	0.0924	−41.0	577.6	536.6	527.3	486.1	−0.0870	1.2761	1.1891
−6	25.80	10.57	0.0946	−40.0	576.8	536.9	526.4	486.3	−0.0847	1.2716	1.1869
−5	26.46	10.32	0.0969	−38.9	576.1	537.1	525.6	486.6	−0.0824	1.2671	1.1847
−4	27.13	10.08	0.0992	−37.9	575.3	537.4	524.7	486.8	−0.0801	1.2626	1.1825
−3	27.82	9.85	0.1015	−36.8	574.6	537.7	523.9	487.0	−0.0778	1.2582	1.1804
−2	28.52	9.62	0.1039	−35.8	573.8	538.0	523.1	487.2	−0.0755	1.2537	1.1782
−1	29.23	9.40	0.1064	−34.7	573.0	538.2	522.2	487.4	−0.0732	1.2493	1.1761
0	29.95	9.19	0.1089	−33.7	572.2	538.5	521.4	487.6	−0.0709	1.2449	1.1740
1	30.69	8.98	0.1114	−32.6	571.4	538.8	520.5	487.8	−0.0686	1.2405	1.1719
2	31.44	8.78	0.1139	−31.6	570.7	539.1	519.7	488.0	−0.0663	1.2362	1.1699
3	32.21	8.58	0.1165	−30.5	569.9	539.3	518.8	488.2	−0.0640	1.2318	1.1678
4	32.99	8.39	0.1192	−29.5	569.1	539.6	518.0	488.4	−0.0618	1.2275	1.1657
5	33.79	8.20	0.1219	−28.4	568.3	539.9	517.1	488.6	−0.0595	1.2231	1.1636
6	34.60	8.02	0.1247	−27.4	567.5	540.1	516.3	488.7	−0.0572	1.2188	1.1615
7	35.43	7.84	0.1275	−26.3	566.7	540.4	515.4	488.9	−0.0550	1.2145	1.1595
8	36.28	7.67	0.1304	−25.3	565.9	540.7	514.6	489.1	−0.0527	1.2102	1.1575
9	37.14	7.50	0.1333	−24.2	565.2	540.9	513.7	489.3	−0.0505	1.2059	1.1554
10	38.02	7.34	0.1363	−23.2	564.4	541.2	512.9	489.5	−0.0483	1.2017	1.1534
11	38.93	7.18	0.1393	−22.1	563.6	541.4	512.0	489.7	−0.0461	1.1975	1.1514
12	39.84	7.02	0.1424	−21.1	562.8	541.7	511.2	489.9	−0.0438	1.1932	1.1494
13	40.77	6.87	0.1455	−20.0	562.0	542.0	510.3	490.1	−0.0416	1.1890	1.1474
14	41.71	6.72	0.1487	−19.0	561.2	542.2	509.4	490.3	−0.0394	1.1848	1.1454
15	42.67	6.583	0.1519	−17.9	560.4	542.5	508.6	490.5	−0.0372	1.1806	1.1434
16	43.65	6.444	0.1552	−16.8	559.6	542.7	507.7	490.6	−0.0350	1.1765	1.1415
17	44.65	6.308	0.1585	−15.8	558.8	543.0	506.8	490.8	−0.0328	1.1723	1.1395
18	45.67	6.176	0.1619	−14.7	558.0	543.2	506.0	491.0	−0.0306	1.1682	1.1376
19	46.70	6.047	0.1654	−13.6	557.1	543.5	505.1	491.2	−0.0284	1.1640	1.1356
20	47.75	5.920	0.1689	−12.6	556.3	543.7	504.2	491.4	−0.0262	1.1599	1.1337
21	48.82	5.796	0.1725	−11.5	555.5	544.0	503.3	491.6	−0.0240	1.1558	1.1318
22	49.91	5.676	0.1762	−10.4	554.7	544.2	502.4	491.8	−0.0218	1.1516	1.1298
23	51.02	5.560	0.1799	− 9.4	553.9	544.5	501.6	491.9	−0.0196	1.1475	1.1279
24	52.15	5.447	0.1836	− 8.3	553.1	544.7	500.7	492.1	−0.0174	1.1435	1.1260
25	53.30	5.336	0.1874	− 7.3	552.2	545.0	499.8	492.3	−0.0153	1.1395	1.1242
26	54.47	5.228	0.1913	− 6.2	551.4	545.2	498.9	492.5	−0.0131	1.1354	1.1223
27	55.66	5.122	0.1953	− 5.1	550.6	545.5	498.1	492.7	−0.0109	1.1314	1.1205
28	56.87	5.019	0.1993	− 4.1	549.8	545.7	497.2	492.9	−0.0087	1.1274	1.1187
29	58.10	4.918	0.2034	− 3.0	549.0	546.0	496.3	493.0	−0.0066	1.1234	1.1168
30	59.35	4.820	0.2075	− 1.9	548.1	546.2	495.4	493.2	−0.0044	1.1194	1.1150
31	60.62	4.724	0.2117	− 0.8	547.3	546.4	494.5	493.4	−0.0022	1.1154	1.1132
32	61.91	4.631	0.2159	+ 0.3	546.5	546.7	493.6	493.6	0.0000	1.1114	1.1114
33	63.22	4.540	0.2203	+ 1.3	545.6	546.9	492.8	493.8	+0.0021	1.1075	1.1097
34	64.55	4.451	0.2247	+ 2.4	544.8	547.1	491.9	493.9	+0.0043	1.1036	1.1079
35	65.91	4.364	0.2292	3.5	543.9	547.4	491.0	494.1	0.0065	1.0996	1.1061
36	67.29	4.279	0.2337	4.6	543.1	547.6	490.1	494.3	0.0087	1.0957	1.1043
37	68.69	4.196	0.2384	5.6	542.2	547.8	489.2	494.5	0.0108	1.0918	1.1026
38	70.11	4.115	0.2431	6.7	541.4	548.1	488.3	494.6	0.0130	1.0879	1.1009
39	71.56	4.036	0.2478	7.8	540.5	548.3	487.4	494.8	0.0151	1.0840	1.0991
40	73.03	3.959	0.2526	8.9	539.7	548.5	486.5	495.0	0.0173	1.0801	1.0974
41	74.53	3.884	0.2575	10.0	538.8	548.8	485.5	495.2	0.0194	1.0763	1.0957
42	76.05	3.810	0.2625	11.1	537.9	549.0	484.6	495.3	0.0216	1.0724	1.0940
43	77.59	3.738	0.2675	12.2	537.1	549.2	483.7	495.5	0.0237	1.0686	1.0923
44	79.16	3.668	0.2727	13.3	536.2	549.4	482.8	495.7	0.0259	1.0647	1.0906
45	80.75	3.599	0.2779	14.3	535.3	549.7	481.9	495.9	0.0280	1.0609	1.0889
46	82.37	3.532	0.2832	15.4	534.5	549.9	481.0	496.0	0.0301	1.0571	1.0872
47	84.01	3.466	0.2885	16.5	533.6	550.1	480.1	496.2	0.0323	1.0533	1.0856
48	85.68	3.402	0.2940	17.6	532.7	550.3	479.2	496.4	0.0344	1.0495	1.0839
49	87.37	3.339	0.2995	18.7	531.8	550.6	478.3	496.5	0.0366	1.0457	1.0822
50	89.09	3.278	0.3051	19.8	531.0	550.8	477.3	496.7	0.0387	1.0419	1.0806
51	90.83	3.219	0.3107	20.9	530.1	551.0	476.4	596.9	0.0408	1.0382	1.0790
52	92.59	3.161	0.3164	22.0	529.2	551.2	475.5	497.0	0.0430	1.0344	1.0774
53	94.38	3.104	0.3222	23.1	528.3	551.4	474.6	497.2	0.0451	1.0306	1.0757
54	96.19	3.048	0.3281	24.2	527.4	551.6	473.6	497.4	0.0473	1.0268	1.0741
55	98.03	2.992	0.3342	25.3	526.5	551.9	472.7	497.5	0.0494	1.0231	1.0725
56	99.90	2.938	0.3404	26.4	525.6	552.1	471.8	497.7	0.0516	1.0194	1.0710

Temp. deg. F.	Pressure, lb. per sq.in.	Sp. vol. sat. vapor, cu.ft. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid.	Latent heat of evap.	Heat content of vapor.	Internal Energy B.t.u. Evap	Internal Energy B.t.u. Vapor	Entropy Liquid	Entropy Evap.	Entropy Vapor
57	101.8	2.885	0.3467	27.5	524.7	552.3	470.8	497.9	0.0537	1.0157	1.0694
58	103.7	2.833	0.3530	28.7	523.8	552.5	469.9	498.0	0.0559	1.0119	1.0678
59	105.7	2.783	0.3594	29.8	522.9	552.7	469.0	498.2	0.0580	1.0083	1.0663
60	107.7	2.734	0.3658	30.9	522.0	522.9	468.0	498.4	0.0601	1.0046	1.0647
61	109.7	2.686	0.3723	32.0	521.1	553.1	467.1	498.5	0.0623	1.0009	1.0632
62	111.7	2.639	0.3790	33.1	520.2	553.3	466.1	498.7	0.0644	0.9973	1.0617
63	113.8	2.592	0.3858	34.2	519.3	553.5	465.2	498.9	0.0665	0.9937	1.0602
64	115.9	2.547	0.3927	35.3	518.4	553.7	464.2	499.0	0.0687	0.9900	1.0587
65	118.1	2.503	0.3996	36.5	517.5	554.0	463.3	499.2	0.0708	0.9863	1.0571
66	120.3	2.460	0.4066	37.6	516.5	554.2	462.3	499.4	0.0729	0.9827	1.0556
67	122.5	2.418	0.4136	38.7	515.6	554.4	461.4	499.5	0.0750	0.9791	1.0541
68	124.7	2.377	0.4207	39.9	514.7	554.6	460.4	499.7	0.0771	0.9755	1.0526
69	126.9	2.336	0.4280	41.0	513.7	554.8	459.5	499.9	0.0792	0.9719	1.0511
70	129.2	2.296	0.4354	42.1	512.8	555.0	458.5	500.0	0.0813	0.9683	1.0496
71	131.5	2.257	0.4430	43.3	511.9	555.2	457.6	500.2	0.0834	0.9647	1.0481
72	133.9	2.219	0.4506	44.4	511.0	555.4	456.6	500.4	0.0855	0.9612	1.0467
73	136.3	2.182	0.4583	45.5	510.0	555.6	455.7	500.5	0.0876	0.9576	1.0452
74	138.7	2.145	0.4662	46.7	509.1	555.8	454.7	500.7	0.0898	0.9540	1.0438
75	141.1	2.109	0.4742	47.8	508.1	556.0	453.7	500.9	0.0919	0.9504	1.0423
76	143.6	2.074	0.4823	49.0	507.2	556.2	452.7	501.0	0.0940	0.9469	1.0409
77	146.1	2.039	0.4905	50.1	506.2	556.4	451.7	501.2	0.0961	0.9434	1.0395
78	148.7	2.005	0.4988	51.3	505.3	556.6	450.8	501.3	0.0983	0.9398	1.0381
79	151.3	1.972	0.5071	52.4	504.3	556.8	449.8	501.5	0.1004	0.9363	1.0367
80	153.9	1.940	0.5155	53.6	503.4	557.0	448.8	501.7	0.1025	0.9328	1.0353
81	156.5	1.908	0.5241	54.8	502.4	557.1	447.8	501.8	0.1047	0.9293	1.0339
82	159.2	1.877	0.5328	55.9	501.4	557.3	446.9	502.0	0.1068	0.9258	1.0326
83	161.9	1.847	0.5416	57.1	500.5	557.5	445.9	502.2	0.1090	0.9222	1.0312
84	164.6	1.817	0.5504	58.3	499.5	557.7	444.9	502.3	0.1111	0.9187	1.0298
85	167.4	1.788	0.5594	59.4	498.5	557.9	443.9	502.5	0.1132	0.9153	1.0285
86	170.2	1.759	0.5685	60.6	497.5	558.1	442.9	502.7	0.1153	0.9118	1.0271
87	173.0	1.731	0.5777	61.8	496.5	558.3	441.9	502.8	0.1175	0.9083	1.0258
88	175.9	1.704	0.5869	63.0	495.5	558.5	440.9	503.0	0.1196	0.9049	1.0245
89	178.8	1.677	0.5964	64.2	494.5	558.7	439.9	503.1	0.1217	0.9014	1.0231
90	181.8	1.650	0.6060	65.3	493.5	558.9	438.9	503.3	0.1238	0.8980	1.0218
91	184.8	1.624	0.6158	66.5	492.5	559.1	437.9	503.5	0.1259	0.8945	1.0205
92	187.8	1.598	0.6258	67.7	491.5	559.2	436.9	503.6	0.1281	0.8910	1.0191
93	190.9	1.573	0.6358	68.9	490.5	559.4	435.9	503.8	0.1302	0.8876	1.0178
94	194.1	1.548	0.6460	70.1	489.5	559.6	434.9	504.0	0.1323	0.8842	1.0165
95	197.3	1.524	0.656	71.3	488.5	559.8	433.9	504.1	0.1344	0.8808	1.0152
96	200.5	1.500	0.667	72.5	487.5	560.0	432.8	504.3	0.1365	0.8774	1.0139
97	203.8	1.477	0.677	73.7	486.5	560.2	431.8	504.5	0.1387	0.8740	1.0127
98	207.1	1.454	0.688	74.9	485.4	560.3	430.8	504.6	0.1408	0.8706	1.0114
99	210.4	1.431	0.699	76.1	484.4	560.5	429.8	504.8	0.1429	0.8672	1.0101
100	213.8	1.408	0.710	77.3	483.4	560.7	428.7	504.9	0.1450	0.8638	1.0088
101	217.2	1.386	0.721	78.5	482.3	560.9	427.7	505.1	0.1471	0.8604	1.0076
102	220.7	1.365	0.732	79.7	481.3	561.1	426.7	505.2	0.1493	0.8570	1.0063
103	224.2	1.345	0.743	80.9	480.3	561.2	425.6	505.4	0.1514	0.8537	1.0051
104	227.7	1.325	0.755	82.2	479.2	561.4	424.6	505.6	0.1535	0.8503	1.0039
105	231.2	1.305	0.766	83.4	478.2	561.6	423.5	505.7	0.1557	0.8469	1.0026
106	234.8	1.285	0.778	84.6	477.1	561.8	422.5	505.9	0.1578	0.8436	1.0014
107	238.4	1.266	0.790	85.8	476.1	561.9	421.4	506.1	0.1599	0.8403	1.0002
108	242.1	1.247	0.802	87.1	475.0	562.1	420.4	506.2	0.1621	0.8369	0.9990
109	245.8	1.228	0.814	88.3	474.0	562.3	419.3	506.4	0.1642	0.8336	0.9978
110	249.6	1.210	0.826	89.6	472.9	562.5	418.3	506.6	0.1664	0.8302	0.9966
111	253.4	1.192	0.839	90.8	471.8	562.6	417.2	506.7	0.1686	0.8268	0.9954
112	257.3	1.174	0.852	92.1	470.7	562.8	416.1	506.9	0.1707	0.8235	0.9942
113	261.2	1.156	0.865	93.3	469.6	562.0	415.1	507.1	0.1729	0.8202	0.9930
114	265.2	1.139	0.878	94.6	468.5	563.1	414.0	507.2	0.1750	0.8169	0.9919
115	269.2	1.122	0.891	95.9	467.4	563.3	412.9	507.4	0.1772	0.8135	0.9907
116	273.3	1.105	0.905	97.1	466.3	563.5	411.9	507.6	0.1794	0.8102	0.9896
117	277.4	1.088	0.919	98.4	465.2	563.7	410.8	507.7	0.1816	0.8068	0.9884
118	281.5	1.072	0.933	99.7	464.1	563.8	409.7	507.9	0.1838	0.8035	0.9873
119	285.7	1.057	0.946	101.0	463.0	564.0	408.6	508.1	0.1859	0.8002	0.9861
120	289.9	1.042	0.960	102.2	461.9	564.2	407.5	508.2	0.1881	0.7969	0.9850
121	294.2	1.027	0.974	103.5	460.8	564.4	406.4	508.4	0.1903	0.7936	0.9839
122	298.5	1.012	0.988	104.8	459.7	564.5	405.3	508.6	0.1925	0.7903	0.9828
123	302.8	0.998	1.002	106.1	458.6	564.7	404.2	508.8	0.1947	0.7870	0.9817
124	307.2	0.984	1.016	107.4	457.4	564.9	403.1	508.9	0.1968	0.7838	0.9806
125	311 6	0.970	1.031	108.7	456.3	565.0	402.0	509.1	0.1990	0.7805	0.9795
126	316.1	0.956	1.046	110.0	455.2	565.2	400.9	509.3	0.2012	0.7772	0.9784
127	320.6	0.942	1.061	111.3	454.0	565.4	399.8	509.4	0.2034	0.7739	0.9773
128	325.2	0.929	1.076	112.6	452.8	565.5	398.7	509.6	0.2056	0.7707	0.9763
129	329.9	0.916	1.092	114.0	451.7	565.7	397.6	509.8	0.2078	0.7674	0.9752
130	334.6	0.903	1.108	115.3	450.6	565.9	396.4	510.0	0.2100	0.7641	0.9741
131	339.4	0.890	1.124	116.6	449.4	566.0	395.3	510.2	0.2122	0.7609	0.9731
132	344.2	0.877	1.140	118.0	448.2	566.2	394.2	510.3	0.2145	0.7576	0.9720
133	349.0	0.865	1.156	119.3	447.0	566.4	393.0	510.5	0.2167	0.7543	0.9710
134	353.9	0.853	1.172	120.7	445.8	566.5	391.9	510.7	0.2189	0.7511	0.9700
135	358.8	0.841	1.189	122.0	444.7	566.7	390.7	510.8	0.2211	0.7478	0.9689
136	363.9	0.829	1.206	123.4	443.5	566.8	389.6	511.0	0.2234	0.7445	0.9679
137	368.9	0.817	1.224	124.7	442.3	567.0	388.4	511.2	0.2256	0.7413	0.9669
138	374.0	0.806	1.241	126.1	441.1	567.2	387.3	511.3	0.2278	0.7380	0.9658
139	379.2	0.795	1.258	127.4	439.9	567.3	386.1	511.5	0.2301	0.7347	0.9648
140	384.4	0.784	1.275	128.8	438.6	567.5	384.9	511.7	0.2323	0.7315	0.9638
141	389.7	0.773	1.293	130.2	437.4	567.6	383.8	511.8	0.2346	0.7282	0.9628
142	395.0	0.762	1.312	131.6	436.2	567.8	382.6	512.0	0.2368	0.7250	0.9618
143	400.4	0.751	1.331	133.0	435.0	567.9	381.4	512.2	0.2391	0.7217	0.9608
144	405.8	0.741	1.349	134.4	433.7	568.1	380.2	512.4	0.2413	0.7185	0.9598

TABLE 2. SATURATED AMMONIA VAPOR: PRESSURE TABLE

Pressure, lb.	Temp. deg. F.	Sp. vol. sat. vapor, cu.ft. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid.	Latent heat of evap.	Heat content of vapor.	Internal Energy B.t.u.		Entropy		
							Evap.	Vapor	Liquid	Evap.	Vapor
1	—103.7	225.	0.0044	.....	644.6	.....	603.0	.....	.....	1.8106	.....
2	— 87.1	117.	0.0085	.....	633.9	.....	590.7	.....	.....	1.7016	.....
3	— 76.5	80.	0.0125	.....	626.9	.....	582.7	.....	.....	1.6362	.....
4	— 68.5	61.	0.0164	.....	621.6	.....	576.5	.....	.....	1.5890	.....
5	— 62.0	49.3	0.0203	—98.1	617.2	519.1	571.5	473.4	—0.2207	1.5522	1.3315
6	— 56.6	41.6	0.0241	—92.5	613.5	521.1	567.3	474.9	—0.2070	1.5222	1.3152
7	— 51.9	35.9	0.0279	—87.6	610.2	522.7	563.7	476.2	—0.1947	1.4964	1.3017
8	— 47.6	31.6	0.0316	—83.2	607.3	524.1	560.4	477.1	—0.1840	1.4739	1.2899
9	— 43.9	28.3	0.0353	—79.3	604.7	525.3	557.4	478.0	—0.1747	1.4540	1.2793
10	— 40.4	25.75	0.0388	—75.7	602.2	526.4	554.6	478.8	—0.1661	1.4362	1.2701
11	— 37.2	23.60	0.0424	—72.4	599.9	527.5	552.0	479.5	—0.1584	1.4201	1.2617
12	— 34.3	21.75	0.0460	—69.4	597.8	528.4	549.6	480.2	—0.1513	1.4053	1.2540
13	— 31.5	20.16	0.0496	—66.5	595.8	529.3	547.4	480.9	—0.1446	1.3916	1.2470
14	— 28.9	18.79	0.0532	—63.8	593.9	530.1	545.4	481.5	—0.1384	1.3788	1.2404
15	— 26.4	17.60	0.0568	—61.2	592.1	530.9	543.3	482.0	—0.1324	1.3668	1.2344
16	— 24.1	16.56	0.0604	—58.8	590.4	531.6	541.4	482.5	—0.1268	1.3556	1.2288
17	— 21.9	15.64	0.0639	—56.5	588.8	532.2	539.6	483.0	—0.1215	1.3450	1.2235
18	— 19.8	14.82	0.0675	—54.4	587.2	532.8	537.9	483.4	—0.1165	1.3350	1.2185
19	— 17.8	14.09	0.0710	—52.3	585.7	533.4	536.3	483.9	—0.1119	1.3256	1.2137
20	— 15.9	13.45	0.0744	—50.3	584.3	534.0	534.7	484.3	—0.1075	1.3167	1.2092
21	— 14.0	12.82	0.0780	—48.4	582.9	534.6	533.1	484.7	—0.1032	1.3081	1.2049
22	— 12.2	12.27	0.0815	—46.5	581.5	535.1	531.6	485.1	—0.0990	1.2998	1.2008
23	— 10.5	11.77	0.0850	—44.7	580.2	535.6	530.2	485.4	—0.0950	1.2919	1.1969
24	— 8.8	11.30	0.0885	—42.9	579.0	536.1	528.8	485.8	—0.0912	1.2843	1.1931
25	— 7.2	10.88	0.0919	—41.3	577.8	536.5	527.4	486.1	—0.0874	1.2770	1.1896
26	— 5.7	10.50	0.0953	—39.7	576.6	536.9	526.1	486.4	—0.0840	1.2700	1.1861
27	— 4.2	10.13	0.0987	—38.1	575.4	537.4	524.9	486.7	—0.0805	1.2633	1.1828
28	— 2.7	9.78	0.1022	—36.5	574.3	537.8	523.7	487.0	—0.0771	1.2568	1.1797
29	— 1.3	9.47	0.1056	—35.0	573.2	538.2	522.5	487.3	—0.0739	1.2506	1.1767
30	+ 0.1	9.17	0.1090	—33.6	572.1	538.5	521.3	487.6	—0.0708	1.2446	1.1738
31	1.4	8.90	0.1124	—32.2	571.1	538.9	520.2	487.8	—0.0677	1.2388	1.1711
32	2.7	8.64	0.1158	—30.8	570.1	539.3	519.1	488.1	—0.0648	1.2331	1.1683
33	4.0	8.39	0.1192	—29.5	569.1	539.6	518.0	488.4	—0.0617	1.2274	1.1657
34	5.3	8.15	0.1226	—28.2	568.1	540.0	516.9	488.6	—0.0589	1.2219	1.1630
35	6.5	7.93	0.1260	—26.9	567.1	540.3	515.8	488.8	—0.0561	1.2167	1.1606
36	7.7	7.73	0.1294	—25.6	566.2	540.6	514.8	489.1	—0.0534	1.2115	1.1580
37	8.9	7.52	0.1328	—24.4	565.3	540.9	513.8	489.3	—0.0508	1.2065	1.1557
38	10.0	7.84	0.1362	—23.2	564.4	541.2	512.8	489.5	—0.0483	1.2017	1.1534
39	11.1	7.16	0.1397	—22.0	563.5	541.5	511.9	489.7	—0.0458	1.1970	1.1512
40	12.2	6.989	0.1431	—20.8	562.6	541.8	511.0	489.9	—0.0433	1.1923	1.1490
41	13.3	6.824	0.1465	—19.7	561.7	542.0	510.0	490.1	—0.0409	1.1877	1.1468
42	14.4	6.668	0.1500	—18.6	560.9	542.3	509.1	490.3	—0.0386	1.1832	1.1447
43	15.4	6.520	0.1534	—17.5	560.0	542.6	508.2	490.5	—0.0363	1.1789	1.1426
44	16.4	6.380	0.1567	—16.4	559.2	542.8	507.3	490.7	—0.0341	1.1747	1.1406
45	17.4	6.247	0.1601	—15.3	558.4	543.1	506.4	490.9	—0.0319	1.1706	1.1387
46	18.4	6.120	0.1634	—14.3	557.6	543.3	505.6	491.1	—0.0296	1.1665	1.1369
47	19.4	5.999	0.1667	—13.3	556.8	543.6	504.7	491.3	—0.0276	1.1625	1.1349
48	20.3	5.883	0.1700	—12.3	556.1	543.8	503.9	491.4	—0.0255	1.1586	1.1331
49	21.2	5.772	0.1733	—11.3	555.3	544.0	503.1	491.6	—0.0235	1.1548	1.1313
50	22.1	5.665	0.1765	—10.3	554.6	544.3	502.3	491.8	—0.0216	1.1511	1.1296
51	23.0	5.562	0.1798	— 9.3	553.9	544.5	501.5	491.9	—0.0196	1.1475	1.1279
52	23.9	5.463	0.1831	— 8.4	553.1	544.7	500.8	492.1	—0.0177	1.1440	1.1263
53	24.8	5.367	0.1863	— 7.5	552.4	544.9	500.0	492.3	—0.0158	1.1405	1.1246
54	25.6	5.274	0.1896	— 6.6	551.7	545.1	499.3	492.4	—0.0140	1.1371	1.1230
55	26.4	5.184	0.1929	— 5.7	551.1	545.3	498.6	492.6	—0.0122	1.1337	1.1215
56	27.3	5.097	0.1962	— 4.8	550.4	545.5	497.8	492.7	—0.0103	1.1303	1.1200
57	28.1	5.012	0.1996	— 3.9	549.7	545.7	497.1	492.9	—0.0084	1.1270	1.1185
58	28.9	4.929	0.2029	— 3.0	549.0	545.9	496.4	493.0	—0.0066	1.1238	1.1170
59	29.7	4.848	0.2063	— 2.2	548.4	546.1	495.7	493.2	—0.0050	1.1206	1.1156
60	30.5	4.770	0.2097	— 1.3	547.7	546.3	495.0	493.3	—0.0033	1.1174	1.1141
61	31.3	4.695	0.2130	— 0.5	547.0	546.5	494.3	493.5	—0.0016	1.1143	1.1127
62	32.1	4.623	0.2163	+ 0.3	546.4	546.7	493.6	493.6	+0.0001	1.1112	1.1113
63	32.8	4.554	0.2196	1.1	545.8	546.9	492.9	493.7	0.0018	1.1082	1.1100
64	33.6	4.487	0.2229	1.9	545.1	547.1	492.2	493.9	0.0035	1.1052	1.1086
65	34.3	4.422	0.2262	2.7	544.5	547.2	491.6	494.0	0.0051	1.1022	1.1073
66	35.1	4.359	0.2294	3.5	543.8	547.4	490.9	494.1	0.0067	1.0993	1.1060
67	35.8	4.298	0.2327	4.3	543.2	547.6	490.3	494.3	0.0082	1.0965	1.1047
68	36.5	4.238	0.2360	5.1	542.6	547.7	489.6	494.4	0.0097	1.0938	1.1035
69	37.2	4.179	0.2394	5.8	542.0	547.9	489.0	494.5	0.0113	1.0910	1.1023
70	37.9	4.121	0.2427	6.6	541.4	548.1	488.4	494.6	0.0128	1.0882	1.1010
71	38.6	4.065	0.2461	7.4	540.8	548.2	487.7	494.8	0.0143	1.0855	1.0998
72	39.3	4.011	0.2494	8.1	540.2	548.4	487.1	494.9	0.0158	1.0828	1.0986
73	40.0	3.958	0.2527	8.9	539.6	548.5	486.5	495.0	0.0173	1.0801	1.0974
74	40.7	3.907	0.2560	9.6	539.0	548.7	485.9	495.1	0.0187	1.0775	1.0962
75	41.3	3.858	0.2592	10.3	538.5	548.8	485.3	495.2	0.0201	1.0750	1.0951
76	42.0	3.811	0.2624	11.0	537.9	549.0	484.7	495.3	0.0215	1.0725	1.0940
77	42.6	3.765	0.2656	11.7	537.4	549.1	484.1	495.4	0.0229	1.0700	1.0929
78	43.3	3.720	0.2688	12.4	536.8	549.3	483.5	495.6	0.0243	1.0675	1.0918
79	43.9	3.676	0.2721	13.1	536.3	549.4	482.9	495.7	0.0257	1.0650	1.0907
80	44.5	3.633	0.2753	13.8	535.8	549.5	482.3	495.8	0.0271	1.0626	1.0897
81	45.1	3.591	0.2785	14.5	535.2	549.7	481.8	495.9	0.0284	1.0602	1.0887
82	45.8	3.549	0.2818	15.2	534.6	549.8	481.2	496.0	0.0297	1.0579	1.0876
83	46.4	3.508	0.2851	15.8	534.1	550.0	480.6	496.1	0.0310	1.0556	1.0866
84	47.0	3.468	0.2884	16.5	533.6	550.1	480.1	496.2	0.0323	1.0533	1.0856
85	47.6	3.429	0.2917	17.2	533.1	550.2	479.5	496.3	0.0336	1.0511	1.0846
86	48.2	3.390	0.2950	17.8	532.5	550.4	479.0	496.4	0.0349	1.0487	1.0836
87	48.8	3.352	0.2983	18.5	532.0	550.5	478.4	496.5	0.0362	1.0464	1.0826
88	49.4	3.315	0.3017	19.1	531.5	550.6	477.9	496.6	0.0374	1.0442	1.0816
89	50.0	3.278	0.3051	19.8	531.0	550.8	477.3	496.7	0.0386	1.0420	1.0806
90	50.5	3.252	0.3075	20.4	530.5	550.9	476.8	496.8	0.0398	1.0399	1.0797
91	51.1	3.216	0.3110	21.0	530.0	551.0	476.3	496.9	0.0410	1.0378	1.0788
92	51.7	3.181	0.3144	21.7	529.5	551.1	475.8	497.0	0.0422	1.0357	1.0779
93	52.2	3.147	0.3178	22.3	529.0	551.2	475.3	497.1	0.0434	1.0336	1.0770
94	52.8	3.114	0.3212	22.9	528.5	551.4	474.8	497.2	0.0446	1.0315	1.0761
95	53.3	3.082	0.3245	23.5	528.0	551.5	474.3	497.3	0.0458	1.0294	1.0752
96	53.9	3.051	0.3278	24.1	527.5	551.6	473.8	497.4	0.0470	1.0273	1.0743
97	54.4	3.021	0.3310	24.7	527.0	551.7	473.3	497.4	0.0482	1.0253	1.0735
98	55.0	2.992	0.3342	25.3	526.5	551.9	472.8	497.5	0.0494	1.0233	1.0726
99	55.5	2.964	0.3374	25.9	526.1	552.0	472.3	497.6	0.0505	1.0213	1.0718
100	56.0	2.936	0.3406	26.5	525.6	552.1	471.8	497.7	0.0516	1.0194	1.0709
101	56.6	2.909	0.3438	27.1	525.1	552.2	471.3	497.8	0.0527	1.0174	1.0701
102	57.1	2.882	0.3470	27.7	524.6	552.3	470.8	497.9	0.0539	1.0154	1.0693
103	57.6	2.855	0.3503	28.2	524.2	552.4	470.3	498.0	0.0550	1.0135	1.0685
104	58.1	2.829	0.3535	28.8	523.7	552.5	469.8	498.1	0.0561	1.0116	1.0677
105	58.6	2.803	0.3568	29.3	523.3	552.6	469.3	498.1	0.0572	1.0097	1.0669
106	59.1	2.777	0.3601	29.9	522.8	552.7	468.9	498.2	0.0583	1.0078	1.0661
107	59.6	2.752	0.3634	30.4	522.4	552.8	468.4	498.3	0.0594	1.0060	1.0653
108	60.1	2.727	0.3667	31.0	521.9	552.9	467.9	498.4	0.0604	1.0042	1.0646
109	60.6	2.703	0.3700	31.5	521.5	553.0	467.5	498.5	0.0614	1.0024	1.0638
110	61.1	2.679	0.3733	32.1	521.0	553.1	467.0	498.6	0.0625	1.0005	1.0630
111	61.6	2.656	0.3765	32.6	520.6	553.2	466.5	498.6	0.0636	0.9987	1.0623
112	62.1	2.633	0.3798	33.2	520.1	553.3	466.1	498.7	0.0646	0.9969	1.0615
113	62.6	2.611	0.3831	33.7	519.7	553.4	465.6	498.8	0.0657	0.9950	1.0607
114	63.1	2.589	0.3863	34.3	519.2	553.5	465.1	498.9	0.0668	0.9932	1.0600
115	63.6	2.568	0.3895	34.8	518.8	553.6	464.6	499.0	0.0678	0.9915	1.0593
116	64.0	2.547	0.3927	35.4	518.4	553.7	464.2	499.0	0.0688	0.9898	1.0586
117	64.5	2.526	0.3959	35.9	517.9	553.8	463.8	499.1	0.0697	0.9882	1.0579
118	64.9	2.506	0.3991	36.4	517.5	553.9	463.4	499.2	0.0706	0.9866	1.0572
119	65.4	2.486	0.4023	36.9	517.1	554.0	462.9	499.3	0.0716	0.9849	1.0565
120	65.8	2.466	0.4056	37.4	516.7	554.1	462.5	499.4	0.0725	0.9833	1.0557
121	66.3	2.446	0.4089	37.9	516.3	554.2	462.1	499.4	0.0735	0.9816	1.0551
122	66.8	2.426	0.4121	38.5	515.8	554.3	461.6	499.5	0.0745	0.9799	1.0544
123	67.2	2.409	0.4153	39.0	515.4	554.4	461.2	499.6	0.0754	0.9783	1.0538
124	67.7	2.390	0.4185	39.5	515.0	554.5	460.8	499.7	0.0764	0.9767	1.0531
125	68.1	2.371	0.4218	40.0	514.6	554.6	460.4	499.7	0.0773	0.9751	1.0524
126	68.6	2.353	0.4250	40.5	514.1	554.7	459.9	499.8	0.0783	0.9735	1.0518
127	69.0	2.335	0.4283	41.0	513.7	554.8	459.5	499.9	0.0792	0.9719	1.0511
128	69.5	2.317	0.4316	41.5	513.3	554.9	459.0	500.0	0.0802	0.9703	1.0504
129	69.9	2.300	0.4348	42.0	512.9	555.0	458.6	500.0	0.0811	0.9687	1.0498
130	70.4	2.283	0.4381	42.5	512.5	555.0	458.2	500.1	0.0820	0.9671	1.0492
131	70.8	2.266	0.4414	43.0	512.1	555.1	457.8	500.2	0.0829	0.9655	1.0484
132	71.2	2.249	0.4447	43.5	511.7	555.2	457.4	500.2	0.0838	0.9640	1.0478
133	71.6	2.233	0.4479	44.0	511.3	555.3	457.0	500.3	0.0847	0.9625	1.0472
134	72.0	2.217	0.4511	44.5	510.9	555.4	456.6	500.4	0.0856	0.9610	1.0466
135	72.5	2.201	0.4544	45.0	510.5	555.5	456.2	500.5	0.0865	0.9595	1.0460
136	72.9	2.185	0.4577	45.5	510.1	555.6	455.8	500.5	0.0874	0.9580	1.0454
137	73.3	2.169	0.4610	46.0	509.7	555.6	455.4	500.6	0.0883	0.9565	1.0448
138	73.7	2.154	0.4643	46.4	509.4	555.7	455.0	500.7	0.0892	0.9550	1.0442
139	74.1	2.139	0.4675	46.9	509.0	555.8	454.6	500.7	0.0901	0.9535	1.0436
140	74.5	2.124	0.4708	47.3	508.6	555.9	454.2	500.8	0.0910	0.9520	1.0430
141	75.0	2.109	0.4741	47.8	508.2	556.0	453.8	500.9	0.0919	0.9505	1.0424
142	75.4	2.095	0.4773	48.3	507.8	556.1	453.4	500.9	0.0928	0.9490	1.0418
143	75.8	2.082	0.4804	48.8	507.4	556.1	453.0	501.0	0.0936	0.9476	1.0412
144	76.2	2.070	0.4835	49.2	507.0	556.2	452.6	501.1	0.0944	0.9462	1.0406
145	76.5	2.057	0.4867	49.6	506.7	556.3	452.2	501.1	0.0952	0.9449	1.0401
146	76.9	2.043	0.489[9]	50.0	506.3	556.4	451.8	501.2	0.0960	0.9435	1.0395
147	77.3	2.029	0.4931	50.5	506.0	556.4	451.4	501.2	0.0968	0.9422	1.0390
148	77.7	2.015	0.4963	50.9	505.6	556.5	451.0	501.3	0.0976	0.9409	1.0385
149	78.1	2.002	0.4995	51.4	505.2	556.6	450.7	501.4	0.0985	0.9395	1.0379
150	78.5	1.989	0.5028	51.8	504.8	556.7	450.3	501.4	0.0993	0.9381	1.0374
151	78.9	1.976	0.5060	52.3	504.4	556.7	449.9	501.5	0.1002	0.9367	1.0368
152	79.3	1.964	0.5092	52.7	504.0	556.8	449.5	501.6	0.1010	0.9353	1.0363
153	79.6	1.952	0.5123	53.1	503.7	556.9	449.2	501.6	0.1018	0.9340	1.0358
154	80.0	1.940	0.5155	53.6	503.3	557.0	448.8	501.7	0.1026	0.9327	1.0353
155	80.4	1.928	0.5187	54.0	503.0	557.0	448.4	501.7	0.1034	0.9313	1.0347
156	80.8	1.916	0.5220	54.5	502.6	557.1	448.0	501.8	0.1042	0.9300	1.0342
157	81.2	1.904	0.5253	54.9	502.2	557.2	447.6	501.8	0.1050	0.9287	1.0337
158	81.5	1.892	0.5286	55.3	501.9	557.2	447.3	501.9	0.1058	0.9274	1.0332
159	81.9	1.880	0.5320	55.8	501.5	557.3	446.9	502.0	0.1066	0.9261	1.0327
160	82.3	1.868	0.5353	56.2	501.1	557.4	446.6	502.1	0.1074	0.9248	1.0322
161	82.7	1.857	0.5386	56.7	500.7	557.5	446.2	502.1	0.1082	0.9235	1.0317
162	83.0	1.846	0.5418	57.1	500.4	557.5	445.9	502.2	0.1090	0.9222	1.0312
163	83.4	1.835	0.5450	57.5	500.0	557.6	445.5	502.2	0.1098	0.9209	1.0307
164	83.8	1.824	0.5483	58.0	499.7	557.7	445.1	502.3	0.1106	0.9196	1.0302
165	84.1	1.814	0.5515	58.4	499.4	557.7	444.8	502.3	0.1114	0.9183	1.0297
166	84.5	1.803	0.5547	58.8	499.0	557.8	444.4	502.4	0.1122	0.9170	1.0292
167	84.9	1.793	0.5578	59.3	498.6	557.9	444.0	502.5	0.1130	0.9157	1.0287
168	85.2	1.783	0.5609	59.7	498.3	558.0	443.7	502.5	0.1137	0.9145	1.0282
169	85.6	1.773	0.5641	60.1	497.9	558.0	443.3	502.6	0.1145	0.9132	1.0277
170	85.9	1.763	0.5673	60.5	497.6	558.1	443.0	502.7	0.1152	0.9120	1.0272
171	86.3	1.753	0.5705	61.0	497.2	558.2	442.6	502.7	0.1160	0.9107	1.0267
172	86.6	1.743	0.5738	61.4	496.9	558.2	442.3	502.8	0.1167	0.9095	1.0263
173	87.0	1.733	0.5771	61.8	496.5	558.3	441.9	502.8	0.1175	0.9083	1.0258
174	87.3	1.723	0.5804	62.2	496.2	558.4	441.6	502.9	0.1182	0.9071	1.0253
175	87.7	1.713	0.5836	62.6	495.8	558.4	441.2	502.9	0.1190	0.9059	1.0249
176	88.0	1.704	0.5869	63.0	495.5	558.5	440.9	503.0	0.1197	0.9047	1.0244
177	88.4	1.694	0.5902	63.4	495.1	558.6	440.5	503.0	0.1204	0.9036	1.0240
178	88.7	1.685	0.5935	63.8	494.8	558.6	440.2	503.1	0.1211	0.9024	1.0235
179	89.0	1.676	0.5967	64.2	494.5	558.7	439.9	503.1	0.1218	0.9012	1.0231
180	89.4	1.666	0.6000	64.6	494.1	558.8	439.5	503.2	0.1226	0.9000	1.0226
181	89.7	1.656	0.6034	65.0	493.8	558.8	439.2	503.3	0.1233	0.8988	1.0222
182	90.1	1.647	0.6068	65.4	493.4	558.9	438.8	503.3	0.1241	0.8976	1.0217
183	90.4	1.639	0.6102	65.8	493.1	558.9	438.5	503.4	0.1248	0.8965	1.0213
184	90.7	1.630	0.6135	66.2	492.8	559.0	438.2	503.4	0.1255	0.8954	1.0209
185	91.1	1.621	0.6168	66.6	492.4	559.1	437.8	503.5	0.1261	0.8942	1.0204
186	91.4	1.613	0.6200	67.0	492.1	559.1	437.5	503.5	0.1268	0.8932	1.0200
187	91.7	1.605	0.6233	67.4	491.8	559.2	437.2	503.6	0.1274	0.8920	1.0195
188	92.1	1.596	0.6266	67.8	491.5	559.3	436.8	503.6	0.1283	0.8908	1.0191
189	92.4	1.588	0.6298	68.2	491.2	559.3	436.5	503.7	0.1289	0.8897	1.0186
190	92.7	1.580	0.6330	68.6	490.9	559.4	436.2	503.7	0.1296	0.8886	1.0182
191	93.0	1.572	0.6362	68.9	490.5	559.4	435.9	503.8	0.1303	0.8875	1.0178
192	93.4	1.563	0.6395	69.3	490.1	559.5	435.5	503.9	0.1310	0.8864	1.0173
193	93.7	1.555	0.6428	69.7	489.8	559.6	435.2	503.9	0.1317	0.8853	1.0169
194	94.0	1.548	0.6460	70.1	489.5	559.6	434.9	504.0	0.1323	0.8842	1.0165
195	94.3	1.541	0.6492	70.5	489.2	559.7	434.5	504.0	0.1329	0.8832	1.0161
196	94.6	1.533	0.6524	70.8	488.9	559.7	434.2	504.1	0.1336	0.8821	1.0157
197	94.9	1.526	0.6554	71.2	488.6	559.8	433.9	504.1	0.1342	0.8811	1.0153
198	95.2	1.519	0.6584	71.6	488.3	559.8	433.6	504.2	0.1349	0.8800	1.0149
199	95.5	1.512	0.6614	71.9	488.0	559.9	433.3	504.2	0.1356	0.8789	1.0145
200	95.9	1.504	0.665	72.3	487.6	560.0	433.0	504.3	0.1363	0.8778	1.0141
202	96.5	1.489	0.672	73.1	487.0	560.1	432.3	504.4	0.1376	0.8757	1.0133
204	97.1	1.474	0.679	73.8	486.4	560.2	431.7	504.5	0.1389	0.8736	1.0125
206	97.7	1.460	0.685	74.6	485.8	560.3	431.1	504.6	0.1402	0.8715	1.0117
208	98.3	1.447	0.691	75.3	485.1	560.4	430.5	504.7	0.1414	0.8696	1.0110
210	98.9	1.433	0.698	76.0	484.5	560.5	429.8	504.8	0.1427	0.8675	1.0102
212	99.5	1.419	0.705	76.7	483.9	560.6	429.2	504.9	0.1440	0.8655	1.0094
214	100.1	1.406	0.711	77.4	483.3	560.7	428.6	505.0	0.1452	0.8635	1.0087
216	100.7	1.394	0.717	78.1	482.

curate experimental work may render necessary a slight revision of the value of the constants in the equations presented. Hence the tabular values resulting from the equations are not to be considered as final, but as best representing the present knowledge of the properties of ammonia.

Of the three tables reproduced, the first and second on pages 60 and 61 are for the saturated vapor of ammonia and give explicitly all of the properties that are ordinarily needed for use. Table 3 gives the thermal properties of liquid ammonia.

TABLE 3. THERMAL PROPERTIES OF LIQUID AMMONIA AT SATURATION PRESSURE

Temp. Deg. F.	Pressure Lb.	Sp. Vol. Cu. Ft. per Lb.	Density Lb. per Cu. Ft.	144 Apv'	Heat Content
—110	0.758	0.02202	45.42	0.003	.....
—105	0.947	0.02211	45.23	0.004	.....
—100	1.176	0.02220	45.04	0.005	.....
— 95	1.450	0.02229	44.85	0.006	.....
— 90	1.778	0.02239	44.66	0.007	.....
— 85	2.167	0.02248	44.47	0.009	.....
— 80	2.626	0.02258	44.28	0.011	.....
— 75	3.164	0.02268	44.09	0.013	.....
— 70	3.791	0.02278	43.89	0.016	.....
— 65	4.518	0.02288	43.70	0.019	.....
— 60	5.358	0.02299	43.51	0.023	.....
— 55	6.324	0.02309	43.31	0.027	.....
— 50	7.43	0.02320	43.11	0.032	—85.67
— 45	8.69	0.02331	42.91	0.038	—80.49
— 40	10.12	0.02342	42.71	0.044	—75.31
— 35	11.74	0.02353	42.50	0.051	—70.13
— 30	13.56	0.02364	42.30	0.059	—64.94
— 25	15.61	0.02376	42.09	0.069	—59.75
— 20	17.91	0.02388	41.88	0.079	—54.56
— 15	20.46	0.02400	41.67	0.091	—49.36
— 10	23.30	0.02412	41.46	0.104	—44.15
— 5	26.46	0.02424	41.25	0.119	—38.92
0	29.95	0.02437	41.04	0.135	—33.68
5	33.79	0.02450	40.83	0.153	—28.43
10	38.02	0.02463	40.61	0.173	—23.17
15	42.67	0.02476	40.39	0.196	—17.89
20	47.75	0.02490	40.17	0.220	—12.59
25	53.30	0.02503	39.95	0.247	— 7.26
30	59.35	0.02518	39.72	0.277	— 1.90
35	65.91	0.02531	39.50	0.309	+ 3.48
40	73.03	0.02547	39.27	0.344	+ 8.88
45	80.75	0.02562	39.04	0.383	+14.32
50	89.1	0.02577	38.81	0.425	19.80
55	98.0	0.02593	38.57	0.471	25.31
60	107.7	0.02609	38.33	0.520	30.87
65	118.1	0.02626	38.09	0.574	36.48
70	129.2	0.02642	37.85	0.632	42.14
75	141.1	0.02660	37.60	0.70	47.84
80	153.9	0.02678	37.35	0.76	53.60
85	167.4	0.02696	37.10	0.84	59.43
90	181.8	0.02714	36.84	0.92	65.32
95	197.3	0.02734	36.58	1.00	71.28
100	213.8	0.02753	36.32	1.09	77.30
105	231.2	0.02774	36.06	1.19	83.39
110	249.6	0.02795	35.79	1.29	89.57
115	269.2	0.02816	35.51	1.40	95.85
120	289.9	0.02839	35.23	1.52	102.24
125	311.6	0.02862	34.95	1.65	108.73
130	334.6	0.02886	34.66	1.79	115.32
135	358.8	0.02910	34.36	1.93	122.02
140	384.4	0.02936	34.06	2.09	128.83
145	411.3	0.02963	33.76	2.26	135.78
150	439.5	0.0299	33.45	2.43	142.87
155	469.1	0.0302	33.13	2.62	150.11
160	500.1	0.0305	32.80	2.82	157.52
165	532.6	0.0308	32.47	3.04	165.11
170	566.6	0.0312	32.03	3.27	172.88
175	602.2	0.0315	31.8	3.51	180.85
180	639.5	0.0318	31.5	3.77	189.03
185	678.4	0.0322	31.1	4.05	197.45
190	719.0	0.0326	30.7	4.34	206.16
195	761.4	0.0330	30.3	4.65	215.18
200	805.6	0.0335	29.9	4.99	.....
205	851.7	0.0340	29.4	5.36	.....
210	899.7	0.0345	29.0	5.75	.....
215	949.6	0.0350	28.6	6.16	.....
220	1001.4	0.0355	28.2	6.59	.....
225	1055.3	0.0361	27.7	7.1	.....
230	1111.3	0.0368	27.2	7.6	.....
235	1169.5	0.0376	26.6	8.1	.....
240	1229.9	0.0384	26.0	8.7	.....
245	1292.5	0.0393	25.4	9.4	.....
250	1357.4	0.0404	24.8	10.2	.....
255	1424.7	0.0417	24.0	11.0	.....
260	1494.4	0.0435	23.0	12.0	.....
265	1566.6	0.0457	21.8	13.3	.....
270	1641.3	0.0500	20.0	15.2	.....
273.2	1690.0	0.0678	14.75	21.2	.....

In tables 1 and 3 the argument is the temperature. Since it is often convenient to be able to work roughly at very high and very low temperatures, these tables have been extended on the one hand to the critical point itself and on the other hand to —110 deg. F. However, since the data upon which the tables are based are not well known at these extreme temperatures, the values above 160 deg. and below about —40 deg. should not be used with too much confidence.

In Table 2 the argument is the pressure. The values above 500 lb. per sq.in., and those below 10 lb. per sq.in. are less certain than those lying between these pressures.

❖

Ammonia to Charge a Compression Plant

The amount of ammonia required to charge a compression plant of a certain tonnage varies somewhat with each individual plant as it depends primarily on the operating pressures, the expansion surface per ton of refrigeration and somewhat on the general layout of the plant. The solution of a specific problem may be of interest.

Take a compressor of 13 tons capacity having a cylinder 7x18 in. and a speed of 70 r.p.m. The condenser is made up of double pipe 20 ft. long and 12 pipes high, the inside water pipe being 1¼ in. in diameter and the outside ammonia pipe 2 in. The brine cooler has double pipe 16 ft. long and 12 pipes high, consisting of a 2-in. inside brine pipe and a 3-in. outside ammonia pipe. Assume a receiver 7½ ft. long and 8 in. in diameter. Then determine the amount of ammonia in pounds required to fully charge the plant, the amount of ammonia for the high- and low-pressure sides, and the ammonia per foot of expansion piping.

A 13-ton compression system, including the refrigerating machine, ammonia condenser, ammonia receiver and the piping connecting these apparatus would require about 150 lb. of ammonia for the first charge. Of this quantity about 20 lb. is needed for the condenser, 50 lb. for the receiver and the balance for the refrigerating machine and the connecting piping. A double-pipe brine cooler of the dimensions given would require approximately 60 lb., making a total of 210 lb. for the system.

When the plant is fully charged and in operation the ammonia receiver should be about one-half full and in this condition will hold about 50 lb. of ammonia.

The quantity of ammonia required for a compression system varies with the size. A 5-ton refrigerating machine would take 20 lb. per ton and a 30-ton refrigerating machine about 10 lb. per ton. For 2-in., direct-expansion piping it is customary to figure 0.15 lb. per ft. of length, and 0.1 lb. per ft. of 1¼-in. pipe. In some plants a larger allowance per foot of piping is made, but the above figures may be safely taken for a plant operating under average conditions.

❖

Ammonia in Brine

The presence of some ammonia in calcium chloride brine does not affect its use in freezing tanks unless the quantity of ammonia is so great that it will prevent the absorption in the brine of a sufficient quantity of calcium chloride for the density required. While the ammonia in the brine will slightly affect its freezing point, it will tend to lower the freezing point rather than raise it. Therefore, if the brine will dissolve sufficient calcium chloride to bring its density up to 90 deg. salometer or thereabouts it can be safely used. This can be tested out by filling a pail with the brine and adding calcium chloride sufficient to raise its density as above stated.

EDITORIALS

Condition of New Jersey's License Law

New Jersey's license law took effect on July 4, 1913, but it is doubtful whether the Steam Engineers' and Boiler Operators' License Bureau will be organized for some time, as the legislature failed to appropriate the necessary funds for carrying out the provisions of this law. The excuse for this is that the law was passed during the closing hours of a special session. For this reason no rules and regulations have been drawn up, and nothing definite can be accomplished until the appropriation is made. This it will be the legislature's duty to do immediately on convening at the next regular session.

The Commissioner of Labor has been advising owners and managers of the plants in which stationary engines or boilers are used to file a memorandum with his office, giving a list of all engineers and firemen who would be in their employ on July 4, 1913, and who would be entitled to licenses without examination as provided for in the law. It would materially assist the Commissioner of Labor if those who should furnish this information will do so promptly, addressing the Commissioner of Labor at Trenton, N. J. It will thus be possible for the Department of Labor to forward the necessary formal application blanks to such owners or managers as soon as the License Bureau is organized, and there should be no difficulty in having these applications sent out and returned within the sixty-day limit prescribed by the Act.

⁂

A Central-Station Mistake

If store current is cheaper than home-made, buy it; otherwise, make it yourself. This, in brief, is and always has been POWER's position on the isolated-plant-central-station question. There are enough who cannot have their own plants and must buy current to give the central stations plenty to do. They should stick to this field. It deserves more of their care and attention, but does not get them because it is business that cannot get away anyhow. It is neglected while every effort is turned on grabbing up all the isolated plants.

To see the avidity with which the central stations are going after the small plants one would think they were trying to stamp out a plague. If the health and police departments of our large cities were correspondingly enterprising, disease and crime would be fast disappearing.

It is all wrong for the central stations to try to close up the isolated plants that are operating economically. If they would be sincere in their reports on the justification of their service in any individual proposition the public would have more confidence in them and it would not be necessary to employ spellbinders as business solicitors.

When a central station goes so far as to offer to operate an isolated plant when it has lost hope of closing it, look out! The argument to the owner will be: "Your business is so and so, we would not attempt to tell you how to run it, but ours is making current and we can operate your own plant cheaper than you can."

The scheme is very insidious, for once inside the plant, and with every interest in seeing it shut down, the central station can hardly be expected to do otherwise than try to strengthen its plea to sell current by running the equipment at a disadvantage. If the central station does save money over the building's operation of its own plant it is mainly, if not almost entirely, in the labor item. With cheaper help, what is likely to happen? Repairs will be neglected, failures of the service will be more frequent, until, if the plan works out as it is meant to, the owner closes down his plant in disgust and buys the current.

Really, it is not half as clever as it at first appears, for it would be a rather stupid owner that would not see through the ruse. Further, the turn about from an argument to sell current, claiming that the plant cannot make it as cheap, to an offer to operate the plant, shows insincerity at once.

The sooner the central stations and all other such companies realize that "public service" means service *of* not *by* the public, the better it will be for all concerned. In other words, they should cling to the fundamental principle that they were created for the public, not the public for them.

⁂

Office-Building Power Plants

Time was, and that not so long ago, when, with scarcely an exception, the mechanical equipment of the office building was considered a necessary evil to be obtained as cheaply as possible and tucked away in obscure corners of a low-ceiling basement with indifferent provisions for ventilation, if any at all, and scant thought of providing for efficiency on the part of either the apparatus or the operators.

Lately, however, ideas in this direction have changed markedly and the best practice today is to lay out the plant with as much thought and effort toward reliability and efficiency as are used in the construction of any other type of plant no matter what its purpose.

The plant of the Otis building, described in this issue, is a case in point. When it is known that its design was supervised by a man who had had large experience in the operation of plants of this type and knew their shortcomings thoroughly, it is no great cause for wonder that especially careful provision was made for accessibility, proper ventilation and the recording of operating data, all rarities in steam plants of a few years ago.

Some may criticize the employment of such devices as air washers as unwarranted or extravagant, but it is doubtful if such criticism is justified. Clean air reduces the accumulation of dust, and humidified air increases personal comfort, especially in the winter time, and hence tends to increase human efficiency. Both of these ends are worth reasonable effort to attain.

Weighing and measuring devices for the systematic accumulation of operating data are coming to be considered almost vital and scarcely a new plant of any kind is erected now without such equipment.

❧

Shipping Power-Plant Equipment

Why American manufacturers have to be continually cautioned to use more judgment and care in shipping goods, especially to the South American markets, seems strange. Competition is sufficiently keen, and surely enough business has been lost to awaken them to the realization that something is wrong.

The trouble is not usually with the design or construction of the equipment but with the manner in which it is shipped. It may be argued that goods are shipped and crated according to specifications, and that if commodities are received broken or deranged, it is the fault of the carriers. However true this may be, it is no consolation to the purchaser. He wants the goods to use. Naturally, those manufacturers whose goods are received so that they are ready to use when assembled, will get more orders than those whose goods are broken and deranged regardless of specifications as to shipping.

The secret of the success of the Germans and the French, and possibly the English, in the South American market is the key to the Americans' failure—poor crating. The successful manufacturers have had the foresight to send South American consignments in especially strong cases and in parts small enough to be readily handled by the tackle and carriers characteristic to those countries. Engines, generators and other machinery for mines, etc., located in mountainous districts must usually be conveyed by mule-back or taken over special highways built at considerable cost.

It may seem proper to ship delicate instruments, for example, Orsat apparatus, electrical meters, etc., in ordinarily heavy cases and with the usual amount of excelsior or other padding, but it is not. Cases and such are usually unloaded from the ships in rope slings and large, heavy cases are likely to crush the smaller ones and their contents when the sling load is landed on the pier. When breakage occurs it means that the engineer, who is anxious to complete an installation or thoroughly test equipment before he leaves it in hands not any too competent, must wait weeks for another instrument to replace the broken one or go home after doing his best under adverse circumstances. Conditions like this sometimes have a doubly injurious effect on Americans. The native owners become dissatisfied with the engineer as well as with the manufacturer.

The suggestion is sometimes heard that fragile or delicate instruments would be more certain to reach their destination safely if taken apart and the pieces packed in separate compartments in one case. This is unquestionably true, but unless competent men were available to assemble the instrument or machine, dissatisfaction would be as strong as ever.

American design and construction of power-plant equipment equals that of any other country. If we used proper methods of crating and shipping and gave thorough consideration to the facilities for handling equipment, no European nation should surpass us in supplying distant markets.

New Ammonia Tables

During late years the field of mechanical refrigeration has broadened. It has been applied to new uses, the machines and apparatus employed are being made larger and better and the total tonnage in refrigerating and ice-making output has had its annual increase. With its increasing importance an accurate knowledge of the properties of refrigerating fluids has become more urgent. For ammonia, the most important of these fluids, a number of tables based upon meager data of various authorities have been used. These tables, giving the properties of ammonia, differ and it is known that all of them contain inaccuracies. For ammonia at a certain pressure and temperature, the tables of Wood and Peabody, which have been considered standard in this country, give different values, and unless the authority is specifically stated in each case, there is opportunity for confusion. The two tables above mentioned appeared in about 1889. Since that time considerable experimental work has increased our knowledge on the properties of ammonia, but even now comparatively little is known, considering the importance of the subject.

For some time the Engineering Experiment Station of the University of Illinois has been doing some interesting work on ammonia. The investigation was undertaken with the object of collecting and correlating the various scattered experimental data. In the words of the investigators an attempt was made to reconcile these data by means of well known thermodynamic laws and principles so that the results may be consistent with each other; and to express the various properties by means of formulas from which tables and charts in English units may be prepared. How well their attempt has succeeded may be inferred from the tables presented in the refrigerating department of this number. Space was not available to give all of the tabular matter contained in the bulletin, an extended table on superheated ammonia vapor being omitted. The authors of the bulletin realized that the experimental data were not as complete as could be desired and that more accurate experimental work may render necessary a slight revision of the values of the constants in the equations used. This being the case the tabular values are not to be considered as final, but as best representing the present knowledge of the properties of ammonia.

It would appear that the tables are as accurate as the present state of the art will permit. At least they are more nearly correct than any of the tables now used, and have been compiled for every degree of temperature and pound of pressure far in excess of the ordinary working limits. They are the Marks and Davis steam tables for ammonia and in preference to a number of tables less accurate it would seem that their universal adoption would be only a matter of course.

❧

Our Cartoon this week is a rather strong "story without words." And how typical of human nature it is that those who are having their enjoyment are rushing heedlessly past the man whose sacrifice of his own pleasure makes theirs possible. Another point is the irony of the title, "The Day of Rest," for there is little rest evident in either half of the picture. Those who can rest will not and because of them others cannot.

READERS WITH SOMETHING TO SAY

Compound-Engine Valve Did Not Operate

In a plant having four cross-compound Corliss condensing engines, one of the night assistant engineers notified the chief that he was ill and could not take his regular watch the coming night, so the chief was compelled to stand it with the aid of an oiler.

Things went smoothly until, at two o'clock in the morning, the lights began to grow dim. The chief hustled around to locate the cause. The engine was not quite up to speed. He found the valve-gear all right; looked over the surface condenser, which showed 27½ in. of vacuum —in fact, there was no apparent cause for the low voltage or three-quarter engine speed. Then the chief told the oiler to speed up another engine.

The troublesome engine was shut down and left for the day-shift assistants to discover the cause. They accidently found the key that fastened the valve stem to the bell crank on the floor.

Of course, the valve-gear would apparently be working all right. The only way to detect this fault would be to ascertain if the valve stem turned, something one would not ordinarily think of, as the arm was lifting and cutting off in a natural manner by turning on the valve stem.

A. C. WALDRON.

Revere, Mass.

Losses for Different CO_2 Percentages

The important factors which affect the operation of boilers are the quality of fuel, its clinkering tendencies, method of firing, draft, tightness of setting, radiation, cleanliness, etc.

Assume a plant consuming 25 tons of coal per day at a cost of $3 per ton and at the usual average of 8 per cent. CO_2. Referring to the table the loss is 34.5c. per ton. Increasing the CO_2 value to 12 per cent. reduces the loss to 14.4c. per ton, and a yearly saving of over $1500.

T. A. LEES.

Quincy, Mass.

CO_2 percent.	Fuel loss percent.	Cost of coal per ton: 2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00
		Loss in cents per ton																		
15	0.022	4.8	5.0	5.2	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5
14	0.029	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6
13	0.038	8.3	8.7	9.1	9.5	9.8	10.2	10.6	11.0	11.4	11.7	12.1	12.5	12.9	13.3	13.6	14.0	14.4	14.8	15.2
12	0.048	10.5	11.0	11.5	12.0	12.4	12.9	13.4	13.9	14.4	14.8	15.3	15.8	16.3	16.8	17.2	17.7	18.2	18.7	19.2
11	0.060	13.2	13.8	14.4	15.0	15.6	16.2	16.8	17.4	18.0	18.6	19.2	19.8	20.4	21.0	21.6	22.2	22.8	23.4	24.0
10	0.075	16.5	17.2	18.0	18.7	19.5	20.2	21.0	21.7	22.5	23.2	24.0	24.7	25.5	26.2	27.0	27.7	28.5	29.2	30.0
9	0.093	20.4	21.3	22.3	23.2	24.1	25.1	26.0	26.9	27.9	28.8	29.7	30.6	31.5	32.5	33.4	34.3	35.3	36.2	37.1
8	0.115	25.3	26.4	27.6	28.7	29.9	31.0	32.2	33.3	34.5	35.6	36.8	37.9	39.1	40.2	41.4	42.5	43.7	44.8	46.0
7	0.139	30.5	31.9	33.3	34.7	36.1	37.5	38.9	40.3	41.7	43.0	44.4	45.8	47.2	48.6	50.0	51.4	52.8	54.2	55.6
6	0.182	40.0	41.8	43.6	45.5	47.3	49.1	50.9	52.7	54.6	56.4	58.2	60.0	61.8	63.7	65.5	67.3	69.1	70.9	72.8
5	0.236	51.9	54.2	56.6	59.0	61.3	63.7	66.0	68.4	70.8	73.1	75.5	77.8	80.2	82.6	84.9	87.3	89.6	92.0	94.4
4	0.316	69.5	72.6	75.8	79.0	82.1	85.3	88.4	91.6	94.8	97.9	101.1	104.2	107.4	110.6	113.7	116.9	120	123.2	126.4

Perfect combustion is not a matter of mere dictation and will be found quite difficult to attain in everyday practice. The same draft is not always available at all boilers in the same room. All settings may not be in perfect order and numerous other difficulties are encountered which frequently are easily remedied and which are always well worth the attention if any improvement in efficiency results. To illustrate the value of attention to boiler operation, the following table is compiled, which shows the amount in money saved by improvement of furnace conditions. Showing the effect of boiler-room conditions in this way, it is felt that a better conception may be had of the value of careful and thoughtful consideration to boiler-room equipment.

Grinding Engine Shaft in Position

Recently I was consulted about a job in a plant where an engineer had allowed the main bearing of a Corliss simple condensing engine to run hot enough to take the babbitt metal from the quarter and the bottom boxes. The shaft had come in contact with the cast-iron shell of the quarter and bottom boxes and was cut to a depth of nearly $\frac{1}{16}$ in. in places. The engine was run in connection with a waterwheel and as the water was very low and the plant had orders calling for early deliveries, I was induced to try to hand dress the shaft and rebabbitt the boxes in position. This procedure, however, proved a failure as the cuts in the shafts sheared the babbitt out of the boxes in a few hours' run.

I then decided to do a good thorough job by grinding the shaft to a smooth surface. The bearing was 26 in. long and 36 in. in diameter. A 1-hp. portable electric grinder was ordered. A pattern was made for a false bearing which was bolted on the side of the main bearing to carry the shaft while grinding. The weight of the shaft and wheel was carried by two heavy screw jacks set under the lugs of the false bearing. The side thrust was also provided for by using screw jacks. The foundation stone projected far enough to set the two heavy jacks on and the side-aligning jack had a footing against a conveniently located brick wall.

It was necessary to remove the eccentrics as the temporary bearing occupied that space on the shaft covered by the eccentrics. The quarter and bottom boxes were left in the pillow block, being backed off so as not to come in contact with the shaft. This was done to catch and support the shaft should anything give way. A tool carriage from a lathe was clamped to the pillow block in an inverted position, with the cross-feed parallel to the axis of the shaft. A plate of cast iron was obtained, planed parallel, and three sets of holes drilled and tapped into it to fasten the grinder, thus making it possible to move the grinder without disturbing the rigging. This

provision was necessary as there was but a 9-in. cross-feed on the tool carriage of the lathe.

As we had no dynamo or electric connection to supply current to the grinder, we borrowed a small generating set for that purpose.

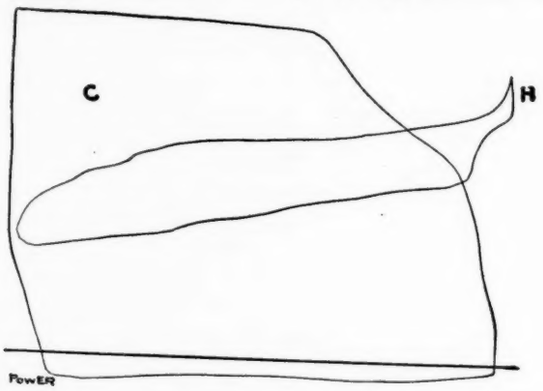
After assembling the outfit and turning the engine shaft for a short time, assuring ourselves that everything was solid and secure, we proceeded to grind the shaft. To drive the shaft the waterwheel gate was partly opened, leaving the engine clutch in, the connecting rod having previously been disconnected. We could in this way control the speed as desired. The shaft was ground until there were only two rings or cuts left in it, as it was not deemed wise to reduce the shaft any more than was necessary. The grinding attachment was then removed and the shaft was lightly filed and then stoned until a very high polish was obtained. In the meantime the boxes were taken out, rebabbitted, bored and scraped to the shaft. After assembling the engine and running light for about five hours, the full load was put on and no trouble whatever was experienced.

F. R. Pratt.

Adams, Mass.

Vacuum-Pump Diagrams for Comment

The accompanying diagrams were taken with a 50-lb. spring from the 8x16-in. steam end of a slide-valve vacuum pump, which makes 85 r.p.m., supplied with steam



Diagrams from Steam End of Vacuum Pump

at boiler pressure of 150 lb. I would like readers to state their opinions as to the probable cause for the imperfections of the diagram from the head end of the cylinder.

William I. Hart.

St. Louis, Mo.

Near Accident to Boiler

What might have resulted in a serious accident in a Western plant recently was averted by the engineer. The 100-hp. return-tubular boiler was erected by a building contractor when the building was built about four years ago.

The boiler was carried by hooks held on I-beams resting on top of a 24-in. side wall, as shown in Fig. 1. Loops were riveted to the shell into which were hooked 1⅛-in. hook bolts, shown in Fig. 2. A 2½-in. extra-heavy blow-off pipe was connected as shown. The engineer went to wash out the boiler and while the boiler was being emptied he decided to grind in the safety valve, which had been leaking. The valve was of the pop-type flange-jointed to the boiler near the rear end and also similarly jointed to a pipe leading outside the building.

As the space over the boiler was limited he decided to take the valve down to the work bench. On removing the last flange bolt the flanges sprang apart with considerable force.

After washing out and refilling the boiler and regrinding the safety valve the engineer started to replace the

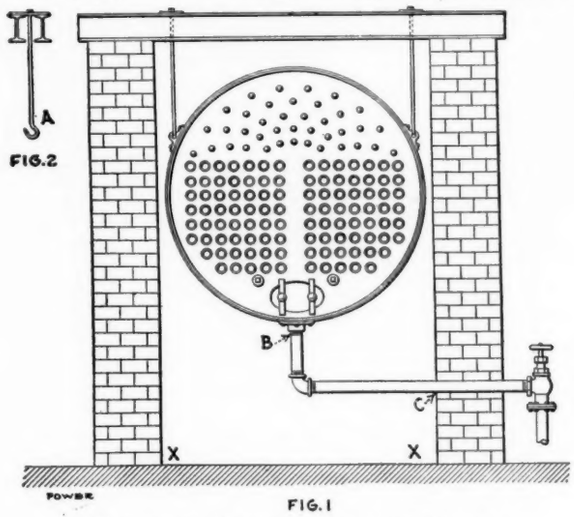


FIG. 1

How the Boiler Was Supported

valve, but found the flanges would not meet nor could not be made to do so by springing the two ends of the pipes. While studying the situation his attention was attracted by the noise of running water. After opening the clean-out door to the combustion chamber and inserting a light, the blowoff pipe was found to be cracked at *B*. He immediately opened the blowoff valve and upon looking in alongside of the blowoff pipe found it was resting hard on the wall at *C*.

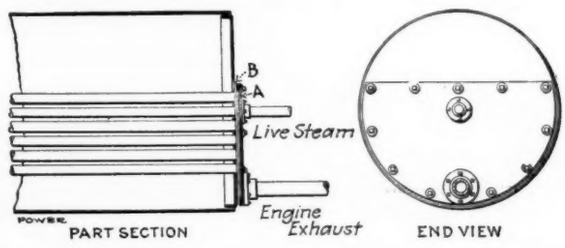
His curiosity now thoroughly aroused, he went on top with a hammer and sounding the suspension rods found them both loose. After removing some of the brickwork, both hooks were found broken at *A*, Fig. 2. The hook ends were found at *XX* in the combustion chamber. Heavy U-bolts were then used to suspend the boiler.

C. F. King.

Portland, Ore.

Old Boiler as Feed-Water Heater

An old boiler unsafe for commercial steam pressures was fitted up to serve as a feed-water heater. A piece of boiler plate *A* was flanged about 1 in. all around the



Part of Boiler Fitted for Heating Feed-Water

edges to form a head over the tube sheet very much as a condenser head appears on a surface condenser. After bolt holes had been drilled in the head plate, a gasket of thick rubber was placed between the head and the boiler

as at *B*. One of these heads was provided for each end of the boiler. The engine is piped to the head as shown and a small live-steam line is connected to the head to furnish steam when the engine is not running. The cost of converting the boiler into a heater did not exceed $30, and it gives entire satisfaction.

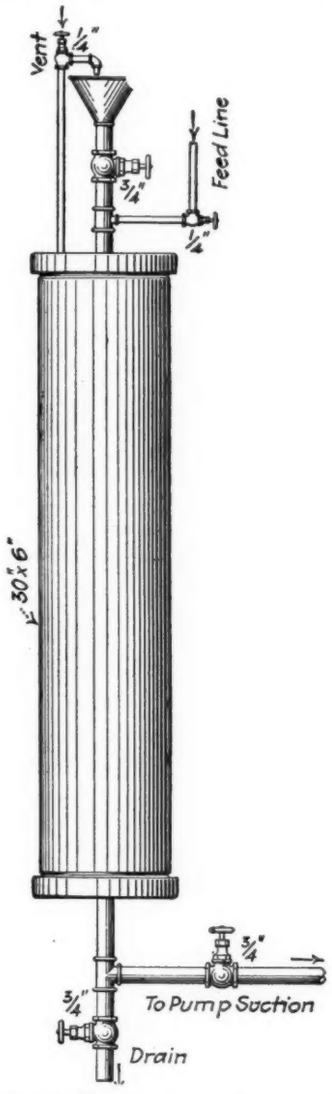
JAMES E. NOBLE.

London Junction, Ont., Canada.

Feeder for Boiler Graphite

This feeder is attached to the suction line of the boiler-feed pump on one side and the other is connected to the boiler-feed line or pressure side.

We mix a boiler compound and the graphite in a pail,



GRAPHITE FEEDER AND CONNECTIONS

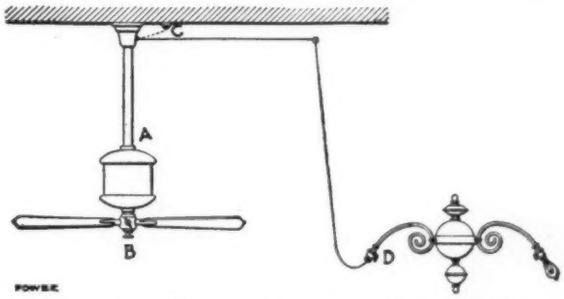
and pour this into the funnel after first draining the tank. To fill, pour the liquid into the funnel, venting the tank at the small ¼-in. line. When full, close the vent and the filling valve, crack the discharge valve to the pump-suction line, then open the filling valve in the line connected to the boiler-feed line filling the tank, which being under pressure, will discharge to the suction line as fast as wanted. By feeding through the suction the graphite goes through the pump. This greatly reduces the maintenance cost of the pump. The discharge can be made to last all day or be emptied in a few minutes.

ASA P. HYDE.

Binghampton, N. Y.

Emergency Repair to Fan Motor

An urgent request was made to operate one of the ceiling fans that was out of order. After being informed by the electrician of the absurdity of the request I decided that the fan must be made to run somehow. The



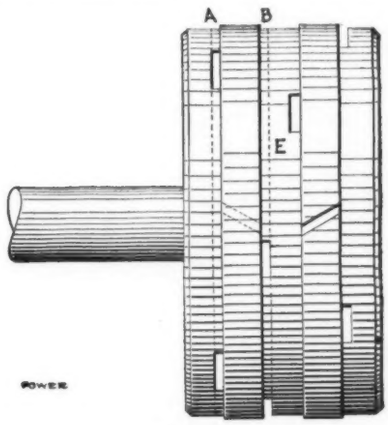
TEMPORARY CONNECTIONS FOR CEILING FAN

fan switch was located at the upper end of the shaft at *A* and was controlled by a rod running through the hollow shaft to the switch button at *B*. The switch was worn beyond repair and the difficulty was overcome by removing the defective switch and connecting the two field wires that formerly went to the switch, after which an extension was spliced to the lines leading to the ceiling socket at *C* and the plug was screwed in the lamp socket at the wall bracket at *D*. The fan was satisfactorily operated until a new switch was procured.

Brooklyn, N. Y. JAMES G. SHERIDAN.

Rings Cause Leaky Piston

The accompanying drawing shows how a leaky piston head was changed to one that would hold. This head had small openings cut on the sides of the ring grooves for the purpose of letting steam beneath the ring, but this steam would flow from the point *E* down beneath the ring



PISTON THAT LEAKED

and across, as shown. Consequently we had a constant leak across the piston. The grooves were widened, as shown by the dotted lines *AB* being turned out in the lathe and new rings fitted. This made the head tight.

Baltimore, Md. C. R. MCGAHEY.

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part IV

Starting where we left off in the last lesson, assume that the apparatus is connected with the gas supply. Connect the burette with the atmosphere by setting the three-way cock with the dot on the handle facing to the right. Then, place the leveling bottle on top of the cabinet and drive all the air out of the burette by opening the pinch cock *R*, Fig. 1, which is again repeated in this lesson, and allowing the water to run in until it reaches the 100-c.c. mark on the upper neck *H*. Now, turn the three-way cock so that the dot faces up, thus connecting the burette and gas supply. Lower the leveling bottle and release the

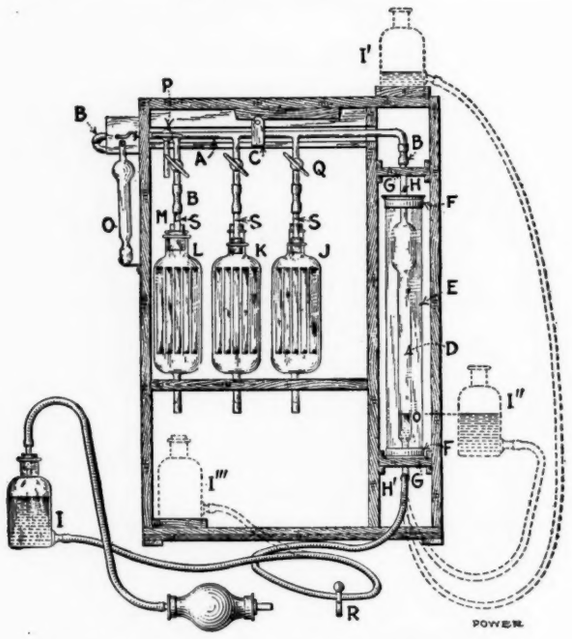


FIG. 1. DIAGRAM FOR ASSEMBLING ORSAT

pinch cock *R* entirely from the rubber connection. Then, connect the small hand pump to the leveling bottle in the manner shown in Fig. 1 and start pumping. If the gas is being drawn direct from the flue or chimney be sure that you pump long enough to secure a burette full of true gas. The amount of pumping required depends upon the length of the connection between the apparatus and the flue. After a little experience you will be able to tell just about how much pumping is required. Remember, however, it is far better to pump a little longer than is actually necessary than not to pump quite long enough. If the gas is being drawn from some kind of collecting apparatus, only a few strokes of the pump will be needed —say, a half dozen.

When you feel sure the burette is full of real gas, cease pumping and immediately give the three-way cock one-eighth turn to the right so that the handle is at 45 deg. and the dot is still on the upward side. Then, put the pinch cock on the leveling-bottle hose at about 6 in. from the burette end, disconnect the hand pump, and place the bottle on top of the cabinet. Now, open the three-way cock to the air by giving it another eighth turn to the right and by carefully releasing the pinch cock from the leveling-bottle hose, run the water into the burette to exactly the zero mark. If, by accident, you permit the water to rise above the zero mark, do not attempt to bring it back by means of the leveling bottle, for this would only let air into the burette and spoil the sample. If you wish, you can proceed with the analysis and make correction by calculation afterward, but I consider it better to simply expel all the gas and start over again. This avoids chance for error later and is about as quick as if you took the time to calculate the correction.

TESTING FOR CO_2

As soon as the water is brought up to the zero mark, close the three-way cock by giving it an eighth turn to the left, and open the cock *Q*, on the first pipette. Squeeze the pinch cock on the leveling-bottle hose and allow the water to rise in the burette to or nearly to the 100-c.c. mark. This forces the gas over into the pipette *J*, the gas driving the liquid from the front leg of the pipette into the back. All the little glass tubes in the front leg are now exposed to the gas and as they are dripping with the solution just driven out, they present a large wetted surface, and, hence, hasten the chemical action between the solution and the gas.

Allow the gas to remain in the pipette about one minute, then draw it back into the burette by lowering the leveling bottle and releasing the pinch cock, using care that none of the solution is drawn over with it. Repeat this operation about three times and then measure the gas as follows: Draw the solution in the pipette up to the mark *S* on the stem and close the cock *Q*. Then, release the leveling-bottle hose entirely from the pinch cock and make the water level in the burette and bottle equal by raising or lowering the bottle at the side of the cabinet as before described. Read the mark at which the water now stands in the burette. If, for instance, the water now stands at the 8.2-c.c. mark, the volume of the gas has diminished 8.2 c.c. in 100, or 8.2 per cent., and that is the percentage of CO_2 in the flue gas. The solution in the first pipette takes out (or absorbs) the CO_2, leaving the oxygen, carbon monoxide and nitrogen.

CHECKING RESULTS

After making the reading, run the gas into the pipette once more and take another reading as a check to make sure that all the CO_2 has been absorbed. If both readings are the same, all right. If not, make one more trial. When reading for CO_2 you should have no trouble in getting the first two readings to agree. If you do have trouble, your method may be wrong and it may be necessary to allow the gas to stand in the pipette a little longer each time or to increase the number of times you run it back and forth. Or, if the solution has been used a long time it may have become weak and need renewing.

A good thing to remember when running the gas from the burette into the pipette and *vice versa* is to watch the rising liquid, in this way eliminating the danger of running any liquid out of the vessel in which it belongs. Thus, when running the gas from the burette into the pipette, watch the water rise in the burette, stopping the flow before it shoots up through the neck *H*, and over through the header into the pipette. When running the gas back, watch the liquid rise in the front leg of the pipette and stop it before it reaches the burette.

Testing for Oxygen

After getting a check on the CO_2 reading, open the cock on pipette *K*, and run the gas back and forth in this pipette in exactly the same manner as before. Only, instead of running it in and out only four times, as in the case with the first pipette, the operation should be repeated about seven times before a reading is taken. The reason for this is that the solution for absorbing oxygen, the part of the flue gas absorbed in the second pipette, does not act as quickly as the solution used in the first pipette for absorbing CO_2.

Check the reading in the same manner as before by running the gas over once more and taking an extra reading. The difference between the new correct reading and the first correct reading gives the percentage of oxygen contained in the flue gas. For instance, if the new reading were 17.6 per cent. and the previous one had been 8.2 per cent., then the oxygen content in the flue gas would be

$$17.6 - 8.2 = 9.4 \textit{ per cent.}$$

Testing for CO

After obtaining a correct reading for the oxygen, open the cock on pipette *L* and go through the same process with this pipette as with the other two, only repeat the operation of running the gas back and forth about 11 times. The solution in this pipette absorbs any carbon monoxide (CO) that may be contained in the flue gas. Its action, however, is very slow and feeble and much care and patience must be used to get a correct reading.

The principle upon which the Orsat apparatus is based is that when certain chemical solutions are brought in contact with certain gases, the gases combine chemically with the solutions in such a way that they become a part of the solution. Ordinary flue gas consists principally of a mixture of carbon dioxide, oxygen and nitrogen and, sometimes, carbon monoxide, hydrogen and some hydrocarbons. When a given volume of such a mixture is brought in contact with a solution of caustic potash and water, the carbon dioxide combines with the caustic potash and forms a substance which becomes a part of the solution. The solution increases in volume but very slightly indeed—so slightly, in fact, that the increase may be entirely neglected in our work. But the volume of the flue gas has diminished by the amount of carbon dioxide it contained.

In a similar way the oxygen and the carbon monoxide disappear from the flue gas when brought into contact with the proper chemical solutions.

The solutions used in the Orsat must be employed in the order here given because the solution for carbon monoxide will absorb oxygen as well, and the solution for oxygen will absorb carbon dioxide, so the CO_2 must be taken out first, the oxygen second and the CO third.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We rather missed the big noise of the Fourth of our younger days, and up to now we'd frown on the "safe and sane" idea. The big noise helped to bang out our appreciation for what was done at Concord, Lexington and Bunker Hill. But when "Collier's Weekly" told us that "in three years New York City yielded 1339 killed and wounded by fireworks," more than our losses in seven Revolutionary battles, it's the front stoop and the red and blue lights for ours; the clang of the ambulance would get on our nerves.

⁂

A Professor Emeritus (his name is really Wadsworth) of the University of Pittsburgh says slang is technical and necessary language. Engineer's plant talk, the mechanic's vernacular, baseball and prize-fight descriptions—what would it all mean divested of its slang? Hooray for the Prof. and on with the slang!

We acknowledge our indebtedness to "Coal Age," for this scintillating gem of thought; it didn't occur to us.

⁂

"Phenix," the New York Leather Belting Co.'s clever little magazine, has an article on "Love." It advocates love during business, but the object must be an "it," not a "she." Concentrated love is idealistic; you must have an ideal if you would love your work. We have known men who said they were wedded to their work, but they soon got a separation on the ground of incompatibility. Perhaps they leaned more heavliy toward the "she" than the "it."

⁂

Overexciting food is responsible for the anarchical doctrines held by many, says a French sociologist. Can we no longer dash the "mulligan" in our suds? Must we eschew our hot dogs, our strenuous Limburger and our outspoken garlic? Is it for these table delicacies that we have anarchistic tendencies?

⁂

The incarcerated British militants may have mixed some of the aforementioned "overexciters" in order to give impetus to their anarchic doings. When jailed, they refused to eat and were forcibly fed through their noses. About four good sniffs of this ménu would either make 'em behave or place 'em beyond the good offices of even the pulmotor.

⁂

Unless you came 'way East, you chaps inland won't see much of the "Imperator." Next to seeing it, however, is to read about it on page 50 of this issue. This ship has pretty darn near everything for safety and comfort but a merry-go-round and a trolley line. And by the way, the Hamburg-American people pronounce it Im-pe-rah-tor, with the accent on the "rah."

⁂

Ever been lost in Perth Amboy? Don't do it. It happened recently to Hoboken Bill Reynolds, Jersey City Jack Callahan and those tender young things "Larry" Brannin, Ed Sears and All-Night Johnson, of Newark. After leaving the Perth Amboy Association meeting, the boys got separated. Bill and All-Night reached home; the others finally landed in the vicinity of the Rahway reformatory. Here they unearthed a hotel and waited for daylight. Some folks think Ed will be the next national conductor, but Cal and "Larry" say he'll never "conduct" them again unless he is armed with an automobile bluebook and a compass.

⁂

In one of Louis Tracy's recent novels an old sea captain, while cruising in the Red Sea, tells the passengers that they don't know what hot weather is. Says he: "Last summer our bunkers gave out six hours north of Perim. We removed the awnings, and then the sun kept up the head of steam in the boilers until we ran into Perim." Might paste this in your kelly to encourage you when the hot days set in.

⁂

First it was Efficiency who had the highest batting average; then he struck out for the bush. Now, it's Uplift who's banging the ball all over the industrial field. Funny, isn't it, how keen we are for a new peg on which to hang our fads and fancies? No matter what other name you call an onion, it's an onion just the same. And they all have their uses.

Functions and Design of Air Chambers

By Charles G. Richardson

SYNOPSIS—Size and location of air chambers, with suggestions on charging chambers with air.

❖

To put the subject interrogatively; first, what is the purpose of air chambers? Second, what are the proper forms and dimensions?

Almost any engineer who has operated reciprocating pumps, large or small, will say that air chambers are for absorbing pulsations. Question him a little further and he will explain that pulsations is simply another word for water-hammer, which usually means blown-out gaskets and irregular pump action with consequent wear and tear on the working parts, and has been known to rupture main pipes or fittings with more or less serious consequences. He may even step over to the boiler-feed pump, open a little wider the cock on the water-pressure gage in the discharge pipe and give a demonstration of pulsations as shown by an oscillation of some 5 to 20 lb. of the dial hand.

For an answer to the second question we turn with confidence to a favorite engineering handbook, but are somewhat chagrined to find no data on the design of air chambers, even if the subject is mentioned at all. A search among borrowed handbooks produces the same result. A friend suggests, however, that air chambers form a regular part of the equipment supplied with pumps, and we hasten to the catalog file. Here some information is obtained; at least some pictures of air chambers are located. It seems rather strange that while the merits of the valves, valve seats, piston rods, plungers and cylinder jackets are all minutely emphasized, no mention is made of the air chamber which shows so conspicuously in the illustration. All shapes and sizes, graceful and otherwise, meet the eye not only in advertising matter, but on pumps in actual service.

FIG. 1

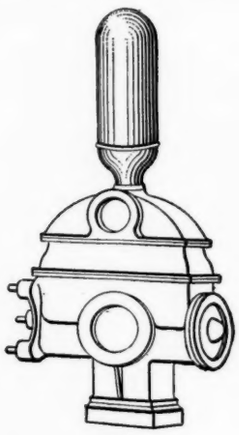


FIG. 2

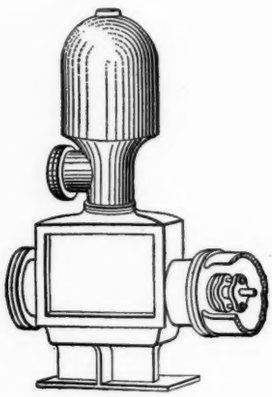


FIG. 3

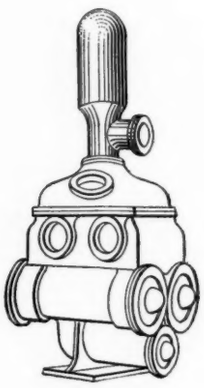


FIG. 4

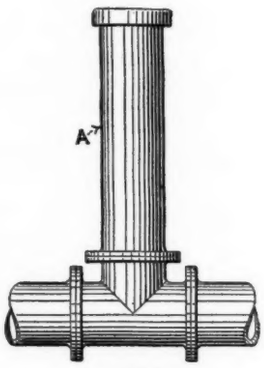


FIG. 5

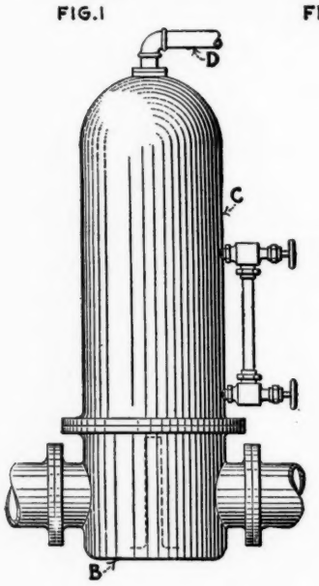


FIG. 6

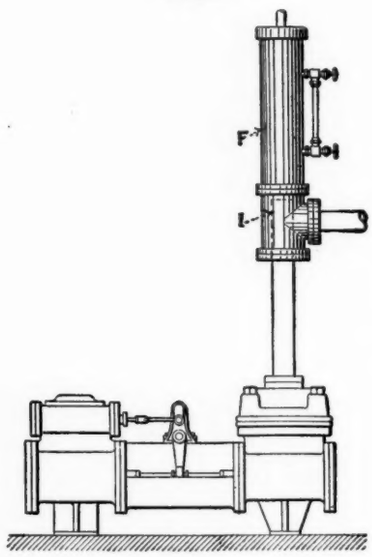


FIG. 7

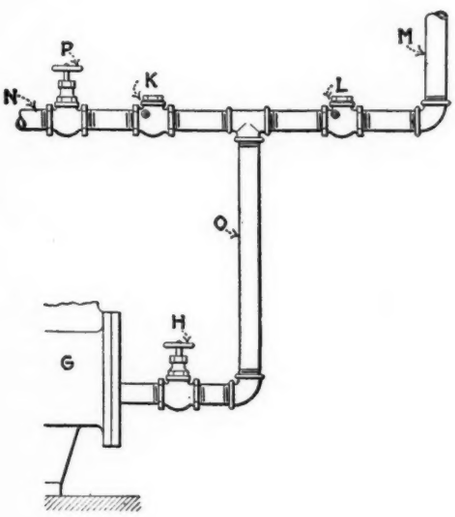


FIG. 8

POWER

The form and proportions of several commercial air chambers are shown by Figs. 1, 2, 3 and 4. Notice the extreme difference in individual ideas of the proper shape and size relative to the pump end. There seem to be two characteristics in common, a neck narrower than the upper portion and the entire absence of means for ascertaining whether the chamber contains any air whatever. Reluctantly it is concluded that reliable information on the subject of air chambers is not available.

This article presumes only to describe the essential features of the properly designed and properly located air chamber. Such conclusions as presented were obtained from repeated tests of equipment under actual operating conditions, chiefly in power plants, and they may serve as a guide for more exhaustive investigations.

Pulsations

To return to the matter of pulsations, it is not often recognized that there are two kinds; pulsations in pressure alone, and pulsations in pressure accompanied by pulsations in velocity. The former are found in the discharge lines of pumping engines on water-works' systems where the friction of several miles of pipe prevents the surging of the water with each stroke of the plungers; the latter is common to boiler-feed lines, which are comparatively short. Both kinds produce water-hammer. In the supply to boilers intermittent flow may also cause irregular boiler feeding and an improper action of automatic apparatus or flow meters depending for accuracy of operation upon a fairly uniform velocity of water. In either kind of pulsations an air chamber is often a necessity, and, if carefully installed, a money saver. The worst offender is the single-cylinder, single-acting pump. Boiler-feed pumps of this kind are occasionally found directly connected to a pumping engine and have a stroke of several feet. As they move slowly and pump water only upon the downward stroke of the plunger, the discharge is exceedingly intermittent. Single-cylinder, double-acting, duplex, triplex and quadruplex pumps follow in the order named. Air chambers are not always found necessary with the duplex pattern and rarely with the triplex. In fact, if the triplex pump is kept in good condition by renewing packings, valves, etc., promptly when needed, an air chamber will not be essential as the column of water in the discharge line is kept moving uniformly, even though the pump may be single acting. The tendency to use centrifugal pumps for boiler feeding and for other kinds of service in the power plant has become pronounced in late years and this type of pump is ideal for giving a steady flow entirely free from pulsations.

Placing the Air Chamber

Fig. 5 illustrates a common method of placing an air chamber in a pump-discharge line. Here *A* is the chamber proper, made from a piece of pipe and a cap, or often from a discarded casting of almost any shape which can be picked up around the plant. The criticism of this arrangement is that the capacity of the chamber is probably not great enough, the flow of the water is at right angles to the air space instead of directly against it as it should be to obtain the maximum cushioning effect, there is no means for determining whether any air is present and no way is provided for recharging the chamber with air when necessary. If it is absolutely necessary to place the air chamber directly in the main line a special casting *B*, Fig. 6, should be made, containing a vertical partition several inches higher than the main pipe connections. On the top of this special may be mounted another casting *C*, of the shape illustrated, or if preferred this top piece can be made up of pipe fittings similar to Fig. 5. A gage-glass should be attached to the lower end of *C*. There should also be a connection *D* of, say, ¼-in. pipe, for charging the air chamber when the gage-glass shows that the air has been partially absorbed. It will be noticed that the course of the water is directed by the baffle against the air space and then has to change its direction again before leaving the chamber.

It is usually possible, however, to locate the air chamber on a tee, as illustrated in Fig. 7. This is a less expensive and fully as effective an arrangement. All of the fittings may be made up from stock pipe and specials. It is essential that the discharge pipe from the pump be carried above the outlet from the tee, as shown at *I*, so that none of the water can pass the tee without coming in contact with the air space in the chamber *F*. This by-passing materially reduces the effectiveness of the air chambers shown in Figs. 1 to 4. It will be noticed that in Fig. 7 the essential features of Fig. 6 have been retained. If there is an objection to the use of a gage-glass, owing to high pressures, two gage-cocks might be employed. Air chambers, however, cannot often be placed in accessible locations and the use of gage-cocks is apt to lead to a falling off in attention.

Air Chamber a Flywheel

It is not often recognized that an air chamber should perform the same functions as the flywheel on an engine; that is, it should store up energy during the forward stroke of the pump and give it out when the pump is reversing. Otherwise, the flow of the water cannot be made uniform and the very purpose for which the chamber was installed is destroyed. In boiler feeding this means that the pressure in the air chamber, and, hence, in the feed line, must be maintained above the pressure in the boilers or else the check valves in the individual feed lines will prevent any water entering the boilers when the pump is reversing; 5 or 10 lb. excess pressure is all that is needed. If this pressure cannot be maintained uniformly by hand regulation, the pumps should be controlled by the ordinary pump governor depending for its action upon the pressure in the discharge line. A curious opposition toward maintaining this slight excess pressure in the feed line seems to exist among many operating engineers. One advanced the objection that the steam consumption would thus be seriously increased, a second figured out the square feet of surface in the heater and concluded that an additional 5 lb. per sq.in. on all this area would result in a wreck. At another plant a meter showed that opening wide the feed valves, which were normally kept "cracked," gave no increase in rate of water to the boilers, showing that the firemen were working under a misapprehension. One prominent Rhode Island electric-railway company keeps an excess pressure of 15 lb. in the feed line. As the chief engineer expresses it: "When the boilers need water I intend they shall get it without a moment's delay." At still another plant, investigation showed that the check-valve disks on every one of the boilers had worn away and dropped through the seats, due to the constant pounding of these valves from pulsations.

Charging Air Chambers

Regarding the charging of air chambers, many plants have compressed air at high pressure which can be connected permanently to the air chamber and used when the gage-glass shows it necessary. Often air can be snifted in through the pump suction by a little careful manipu-

lation of a small air valve connected to the pump-suction pipe. This air valve should be preferably of the needle-valve type so as to permit close regulation; otherwise the pump may become air-bound. A simple and effective method of using the pump itself to fill the air chamber is illustrated in Fig. 8, where G is the pump cylinder, P a regulating valve and K and L check valves. Pipe M leads to the air chamber and N is open to the atmosphere. By opening P a little a column of air may be drawn into the vertical riser O through the check valve K. When the pump plunger reverses, this air is driven out through check valve L into the air chamber. Pipe O should be at least 2 ft. long. Valve H is always kept open except when disconnections are made. This arrangement is not presented as new, as several engineers have independently thought of the same idea and are using it successfully. The control of the air inlet at P instead of at H is thought to be original, however, and this permits an unobstructed passageway between the pump cylinder and the air chamber, facilitating charging. If the water is taken by the pump from an open heater above, pipe O must be made of a length sufficient to place the check valves and the air inlet N above the water level in the heater. If this is not feasible, an air connection can be made directly to N from the compressed-air system, assuming that there is a pressure greater than that due to the head of water in the heaters so that air will be forced into pipe O upon the opening of the check valve K.

One interesting test was run under the following conditions: Single-cylinder, single-acting boiler-feed pump direct connected to a pumping engine; discharge line 2 in. in diameter and about 250 ft. long; water pumped into an open tank through throttling valve on the end of the discharge line; 10-in. by 10-ft. air chamber located in the discharge line close to the pump. An absolutely steady flow of water into the tank was obtained with the throttling valve partly closed, showing that the air chamber was absorbing the extreme pulsations from the type of pump used.

Air Chamber Dimensions

With the exception of the single-cylinder, single-acting direct-connected pump, which is not often found in power plants, and which is diminishing in favor, the dimensions of the air chamber should be sufficient to provide an air space from five to six times the displacement of one pump plunger. The size of discharge lines bears a fairly constant ratio to pump capacity and satisfactory results have been obtained from air chambers of the following dimensions:

Size of Discharge Line In.	Inside Dia. of Air Chamber, In.	Total Height of Air Chamber, Ft.
2	8	2
2½	8	2½
3	10	3
4	10	4
5	12	5
6	16	6

It will be noticed that the height in feet corresponds to the diameter of the line in inches. If there is not head room enough, the chamber may be reduced in height and increased in diameter, retaining the same volume and making the neck as large as the second column of the table.

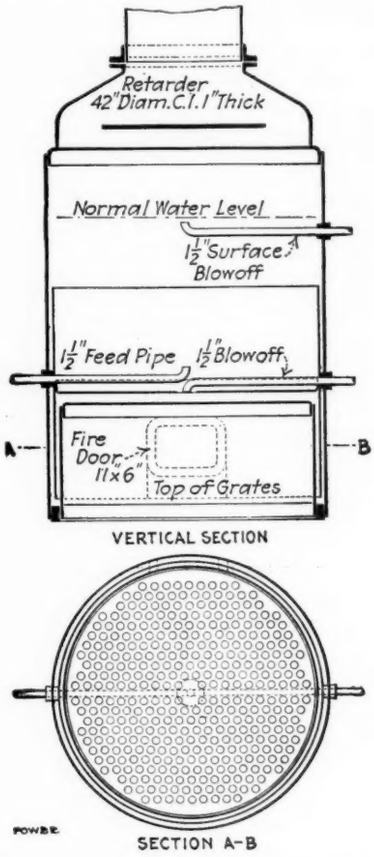
It is hoped that other contributions to this subject will follow as there is certainly great need for air-chamber standardization.

Small Vertical Boiler of High Capacity

By Charles F. Prescott

The writer was asked to install about 80 commercial boiler horsepower in a space only 7 ft. wide by 10 ft. long by 8 ft. 4 in. high. These dimensions were much too small for any usual type of boiler of such capacity.

The only type which looked at all feasible was the vertical, tubular, and as it is considered to be troublesome when of large size, the writer hesitated, but finally decided to build one for the work. The dimensions have been omitted in the illustration for the purpose of more clearly bringing out the fixtures adopted to secure a good circulation of the water and gases.



Showing General Construction of High-Capacity Boiler

The boiler was 72 in. outside diameter and 8 ft. 1½ in. high, and contained 366 two-inch tubes, 5 ft. 5½ in. between sheets, the heating surface of the firebox is 50.9 sq.ft., of the tubes below the water line 758.6 sq.ft., and above the water line, 287.5 sq.ft. Total evaporative heating surface 809.5 sq.ft. The grate surface is 23.22 sq.ft., giving a ratio of heating to grate surface 34.9 to 1.

To secure a rapid circulation of the water and offset the tendency of vertical boilers to accumulate scale on the crown-sheet, or the firebox, the writer devised the pan shown. This was made of steel plates, $\frac{3}{16}$ in. thick, the circular plate extending upward to a point 18 in. below the water line and downward to within 2½ in. of the mud ring.

The flat plate was drilled for the tubes using the firebox plate as a template and in addition to the tube holes,

had a 7-in. hole in the center. The pan was set in the boiler with the flat plate 2½ in. above the crown-sheet and held in place by the firebox stay-bolts which passed through the lower portion.

With this pan in position the circulation is strong, and positive as the intense heat from the firebox will cause the water and steam to rise in the pan, pass rapidly across the crown-sheet and through the central opening, the downward flow being supplied from the top of the pan to the bottom of the boiler by the space between the pan and the shell.

In addition to this natural action the boiler was supplied with feed water at the center by a pipe with the end upturned, so that whenever the pump was running the rapidity of the circulation was increased. The blow-off pipe was turned downward into the central opening and when used caused a flow of water from the firebox.

It will be noted that the tubes are laid off on triangles. In this case, this arrangement is not at all unfavorable as with a nozzle turned at 60 deg. on the end every row of tubes can be washed thoroughly. I have known this boiler to be in constant use for eleven weeks, using only the blowoffs for cleaning, and when opened there was a very small quantity of soft mud, mostly in the pan. No provision was made for washing the crown-sheet directly as the movement of the water was relied upon to keep it swept clean.

When first put in service there was no retarder in the hood and the firebox ends of the central tubes leaked badly. It was surmised that this was due to short-circuiting of the gases, causing most of the heat to go to the center. The retarder was suspended over the center tubes, brackets not shown, and no further trouble was experienced.

The draft was supplied by a stack 30 in. in diameter and 30 ft. high from the grates. The pressure carried was 125 lb. and the feed water was supplied at 155 deg. F. The coal used had an evaporative efficiency of 12½ lb. of water from and at 212 deg. F. Burning 370 lb. of coal per hour, the evaporation was 2920 lb. per hour from and at 212 deg. F., corresponding to 84.6 commercial horsepower.

Readers will find that some very important ratios are wrong in this boiler, when compared to good practice. The boiler would have been a failure had it not been for the circulating pan, which not only kept the heating surfaces clean, but by rapid movements of the water increased the capacity of those surfaces.

There is no doubt that the retarder did its share. The steam averaged 98 per cent. dry. To clean the flues we threw salt on the fire.

Ohio Boiler-Inspection Rules

In compliance with the recently amended Ohio steam-boiler-inspection law, the Ohio Board of Boiler Rules held a special meeting at the State House, Columbus, on July 7.

The purposes of the meeting were to formulate rules covering the construction and inspection of locomotive boilers installed and operated in the state which are not subject to inspection under the Federal laws; to formulate rules governing the construction of furnace flues in internally fired boilers; to revise the safety-valve rules to meet the requirements of modern steam-boiler practice.

Chairman C. H. Wirmel, of the state board, published an announcement of the above object of the meeting as required by law. An early issue of "Power" will contain the report of the proceedings.

Why the Chicago Federal Building Is To Have Its Own Plant

So much prominence has been given to the decision of the present administration to have the Chicago Federal Building furnish its own electric current, that the following history of the events leading up to it may be of interest.

The first important move was the investigation by Government engineers to ascertain whether or not an isolated plant would pay. Their report was rendered in July of last year and showed that the current was being purchased on a sliding scale that made its average cost 1.9c. per kw.-hr. It was estimated that with its own plant the building could be supplied with current at a cost of not to exceed 1.1c. per kw.-hr. The building already contained a plant for steam heating and the boiler equipment would not have to be increased. The help employed now numbering 22 men would have to be increased by only four men and the additional cost for labor would be less than 17½ per cent.

Where, for the heating, there had been consumed about 5600 tons of coal per year, it was figured that 2100 tons more would supply lighting and elevator power as well, the exhaust steam being used for heating. This was based on generating as much current as has been used per year recently, about 1,373,000 kw.-hr. and coal costing $3.15 a ton.

The report recommended the installation of a plant consisting of two 200-kw. and two 100-kw. generating sets and estimated that the saving would pay for the investment in three years.

Before bids were asked the central station was advised that an installation was contemplated and asked to make its best proposition on continuing to furnish current. It replied that the rate then (1.9c. per kw.-hr.) was the best it could make. Nevertheless about the time the bids were opened it offered to reduce the rate. This offer was considered and rejected. The central station then criticised the estimated cost for the building to furnish its own current as inaccurate, claiming that the current could not be made at so low a price.

Comparison of the costs at other Government buildings furnishing their own current showed all to be below the rate offered by the central station. To be sure the estimate was not too low it was checked by engineers in other Government departments and confirmed.

Negotiations became so complicated that no decision was reached during the last administration and it was passed on to the present one. It was not until April that any important new developments occurred. The last proposal of the central station was rejected as it was still above the estimated cost of the current generated in the building's own plant, and Secretary McAdoo ordered the contract awarded to the Harrisburg Foundry & Machine Works, which was low bidder on the basis of an evaluated guarantee.

The clause in the specifications by which the bids were compared is an interesting one and is in effect the same as has been incorporated in similar bids for the last year or so. It gives the Government the chance to close with the most favorable bid rather than as heretofore taking the lowest bid irrespective of value received as a whole. It follows:

COMPARISON OF BIDS—No bids will be considered upon apparatus having a greater steam consumption for the combined units than the amounts hereinafter specified under the heading "Steam Consumption," and in case the guaranties of various bidders differ they will be evaluated as follows for the purpose of comparison:

Cost to generate steam 16 (sixteen) cents per thousand pounds, and steam consumption guaranties will be evaluated at this rate. Each unit will be assumed to operate 8 hours a day, 365 days per year, and at the following load factor:

Percentage of load, per cent.....	25	50	75	100	125
Load factor, per cent.....	10	20	50	15	5

The algebraic sum of the savings at various loads when operating under conditions given above will represent the gross savings per year effected by the units with the lower steam consumption over the units with the higher guaranties.

If the gross yearly savings as computed above exceeds 10 per cent. depreciation and 3 per cent. interest charges on the difference between the amount of the bids, the bid for the units with the lower steam consumption will take preference in the award over the bid for the units with the higher guaranties.

Should the successful bidder fail to fulfill his contract guarantee, the Government is protected by the following clause:

PENALTY—It must be distinctly understood to be one of the conditions under which bids are submitted for the work embraced in the specification that the engines and generators will meet every requirement of the specifications and the guaranteed amounts for steam consumption named by the bidder, under which conditions the contract price will be paid. In event the units fail to meet the specification requirements or the steam consumption is greater than that guaranteed by bidder, the department shall have the right to reject the unit or units absolutely and require the supply of satisfactory unit or units which shall comply with all contract requirements in

regard thereto; or if it elects to accept same in event steam consumption, at any load, is greater irrespective of other loads than that named in the proposal, then the contract price shall be the amount named in the contract for a satisfactory plant less the amount of deficiencies shown by test based on the following schedule for each pound or fractional part of a pound of steam per kilowatt-hour:

	Load				
	25 per cent.	50 per cent.	75 per cent.	100 per cent.	125 per cent.
100-kilowatt-hour unit	$30	$120	$420	$180	$75
200-kilowatt-hour unit	60	240	840	360	150

In the estimate the total cost of operating the plant for the production of current was calculated at somewhat less than $15,000 per annum, which would be a saving of some $11,000 over the cost of purchased current. On the basis of the contractor's guarantee it is likely that this saving will be considerably exceeded.

German Excursion of the American Society of Mechanical Engineers

Upon the invitation of the Verein Deutscher Ingenieure some 250 members and guests of the American Society of Mechanical Engineers left New York on the "Victoria Luise," of the Hamburg-American Line to attend the annual meeting of the Germany Society at Leipzig and to visit, under the auspices of that society, a number of the cities and industrial establishments of Germany. The first stage of the trip ended with the arrival of the steamer at Plymouth, England, one week after leaving New York.

The trip was exceptionally quiet as regards sea and weather, affording the fullest opportunity for the enjoyment of the program provided by the entertainment committee. Every hour was fully occupied; the principal evening events being:

Wednesday—Reception by the officers of the S.S. "Victoria Luise" and of the Society, followed by a dance.

Thursday—Lecture on German history by Henry Hess.

Friday—Mock trial.

Saturday—Lecture on German art by Prof. H. E. Clifford.

Monday—Lecture on German cities by W. R. Warner.

Tuesday—Cotillion.

Wednesday—Lecture on German educational system by Prof. C. R. Richards, and a cabaret performance.

In addition to these main events there were sports, games and contests of various sorts. On Sunday evening, the twenty-fifth anniversary of the accession of the present ruler, Emperor Wilhelm II, a special dinner was served at which the captain proposed the health of the Kaiser, and Dr. William H. Carpenter, vice-president of Columbia University, and president of the Germanistic Society of America, made appropriate remarks. On the following evening a special dinner was given to the Society and on Tuesday evening a farewell dinner to those who were to leave at Plymouth.

The company included engineers from all sections of the United States, representing all branches of engineering and by no means the least profitable of the advantages of the voyage were the impromptu discussions, not programmed, but always in order and in process in every saloon and upon every deck.

Representatives of the Verein met the boat at Cherbourg and the land program commenced at Hamburg, where the party arrived late on Thursday.

NEW PUBLICATIONS

RESUSCITATION. By Dr. Chas. A. Lauffer, Medical Director, Westinghouse Electric & Mfg. Co., East Pittsburgh, Penn. Published by John Wiley & Sons, New York. Size, 4x6½ in.; 47 pages, illustrated, cloth.

This book includes a reprint of a paper on this subject delivered by the author before the Philadelphia Section of the National Electric Light Association. The author, after explaining a number of successful results which have been obtained from employing resuscitation methods on men who were supposedly dead, gives a clear description of the mechanism of respiration, illustrating it by a number of views of the various parts of the anatomy.

The prone pressure, or Schafer method of resuscitation, which has been adopted by the National Electric Light Association, and a number of other engineering societies, is described in detail.

This book emphasizes the need of having the general public acquainted with the principles of resuscitation, and clearly shows how they can be learned so as to prove of valuable assistance to persons in the ordinary walks of life.

PERSONALS

B. F. Wilcox, formerly an operating engineer in the Public Service Corporation plant, at Marion, Jersey City, N. J., has been appointed chief engineer of that company's Trenton plant.

Albert Sheather, assistant chief engineer of the Public Service Corporation power plant, Elizabeth, N. J., has been awarded the gold watch fob offered by the state educational committee, N. A. S. E., of New Jersey, for having given the most correct answers to the 63 questions recently asked by that committee. Mr. Sheather is an officer of Elizabeth Association No. 14.

TRADE CATALOGS

Detroit Lubricator Co., Detroit, Mich. Catalog No. 36L. Locomotive lubricators. Illustrated, 56 pages, 5x8 inches.

De Laval Steam Turbine Co., Trenton, N. J. Catalog C. Steam turbines, velocity-stage type. Illustrated, 108 pages, 6x9 inches.

Henry R. Worthington, 115 Broadway, New York. Bulletin No. 202. Volute centrifugal pumps. Illustrated, 62 pages, 6x9 inches.

The Leavitt Machine Co., Orange, Mass. Catalog No. 16. Improved Dexter valve reseating machine. Illustrated, 28 pages, 7½x9 inches.

Sprague Electric Co., 527-31 W. 34th St., New York. Catalog No. 521. Flexible steel-armored hose. Illustrated, 16 pages, 5¾x8 inches.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 127. Pneumatic drills, reamers, flue rolling and tapping machines, etc. Illustrated, 40 pages, 6x9 inches.

Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill. Bulletin No. 58-M. Cross compound power-driven air compressors. Illustrated, 20 pages, 6x9 inches. Booklet No. 112. Air compressors. Illustrated, 32 pages, 3x5½ inches.

The Smooth-On Mfg. Co., 572-574 Communipaw Ave., Jersey City, N. J., has just issued a helpful 16-page booklet, "Extracts from Smooth-On Instruction Book No. 12," which anyone interested in economical power-plant repair work can have by writing to the company.

The Nicholson File Co., Proxidence, R. I., has just published the eighth edition of "File Filosophy"—"a 49 years' education on files in an hour." "File Filosophy" is a handsome booklet full of helpful file information—in fact it is used as a textbook in many colleges, manual training schools, etc. It is sent free on request.

BUSINESS ITEMS

The firm of Barrett & Walsh Co., in the Chamber of Commerce Building, Detroit, are conducting their business under the name of the Power Plant Supply Co., with James E. Walsh as manager. Among others the company represents the Wm. B. Pierce Co., G. L. Simonds & Co., Laclede Christy Clay Products Co., Martin Grate Co and Bonner & Barnewall.

Wm. B. Merrill & Co., manufacturers of the well known Tripp metallic packing, having found their Boston plant too small to handle the growing demands for this packing, have moved to Jamaica Plain, a suburb of Boston. They now occupy the entire brick and concrete building recently built by the Lenox Automobile Co., where they have ample room and facilities for handling their rapidly growing business.

The American Engineering Co., Philadelphia, has recently secured orders for "Taylor" stokers from the New York, New Haven & Hartford R.R. Co., Cos Cob Conn.; the Narragansett Brewing Co., Providence, R. I.; the General Electric Co., West Lynn, Mass.; the Boston Woven Hose & Rubber Co., Boston, Mass.; the Dominion Iron & Steel Co., Sydney, N. C.; the American Brass Co., Waterbury, Conn.; the Bay State Street Ry. Co., Chelsea, Mass.; the Tremont & Suffolk Mills, Lowell, Mass.; the Cochrane Chemical Co., Boston, Mass.; the Montreal Electric Light & Power Co., Montreal, Canada; the United Illuminating Co., New Haven and Bridgeport; the Detroit Edison Co., Detroit, Mich.; the Philadelphia Electric Co., Philadelphia, Penn.; The Elmira Water, Light & R.R. Co., Elmira, N. Y.